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THE OLSEN TESTING MACHINE.

[*With abstract of the report of the Committee on Science and the Arts thereon.*]

The Olsen testing machine is the result of continued efforts of the inventor to improve his original machine and to meet the additional requirements demanded by progress in the arts of metallurgy and constructions in metal. The earlier investigators in these arts were careful to ascertain the ultimate strength of materials; afterwards a knowledge of the properties of elasticity and ductility were deemed important and were crudely examined into by bending specimens under the hammer. As the art of making structural work progressed, these properties became of importance in estimating the strength and durability procurable by selections of material and questions of cost were affected by such selections. Exact ascertainment and expressions of all of the properties, ultimate strength, limits of elasticity, both in dimensions and in force, and

limits of ductility, expressed in force and dimension, were all demanded for intelligently applying materials to use, as well as for comparing the values of different materials.

The mode of testing these properties or functions of materials under strain, by weighing, and ocularly observing the weight and measuring from time to time by hand the variations in distance of marks previously made upon the specimen, as they changed under the stress applied, was found to be too slow and uncertain, and, therefore, very unsatisfactory, first, because there were so many tests required and the making of them was too long and tedious, and second, the changes which took place during tests occurred in such rapid succession as often to defy accurate observation.

Mr. Olsen's machine is designed to meet these requirements and furnish easy means of prompt application of the specimens to the machine, and of adjustment of the machine to the specimens, with the least requirements in preparation.

To give a clear conception of this machine, it is well to view the instrumentalities by which each function is performed, and afterwards state their combined operation.

First in order is the gripping mechanism for holding the specimen to try its properties under extension.

This consists of wedges, which, under the strain of pulling, are forced toward each other by passing into converging spaces in the draw-heads. To these wedges are attached links, levers and a counterbalance, which enable the operator easily to open and close them, to insert the specimens, before stress is applied, and plungers with adjusting screws for varying the width of the converging space in which the jaws are drawn, to close them so as to adapt them to specimens of different thicknesses.

Second, the means for adjusting the distance of the draw-heads and applying stress and of varying and of graduating the rate of applying the stress.

These consist of a series of four screws attached to the lower draw-head containing the lower set of gripping jaws, which screws and connected parts are drawn downward by nuts turned by a series of toothed wheels and pinions enclosed

in the base of the machine. This train of wheels and pinions is propelled by a shaft projecting from the side of the base and bearing a large spur wheel, which may be actuated rapidly by an idle wheel turned by a large pinion and intermediate upon the shaft bearing the driving pulleys, or, by sliding the large pinion out of gear from the driving shaft and engaging a small pinion in gear with a large spur wheel which turns with it upon the same axis and turns a small pinion engaging in the large spur wheel on the side of the base. This last adjustment effects a great multiplication of force with a corresponding decrease of motion of the screws and connected draw-head.

In addition to this provision for changes of speed, there are placed in the driving shaft a large and a small band-wheel, either of which may, by friction clutches, be alternatively engaged with the driving shaft. By means of these the shaft can be turned rapidly for the purpose of applying small force and quickly moving the draw-head into position to receive the specimens, or with less speed and with greater force, to apply stress to the specimens.

Thus far as described, there are four different adjustments of speed and force in applying motion to the draw-head, all of which are prompt and positive in their action. There is yet another, susceptible of fine graduation and instant control. This is effected by a large grooved friction wheel upon the end of the driving shaft, that may at will be turned by a small wheel upon a small shaft, in constant motion, and that can be pressed into constant engagement and released by the hand of the operator by means of a nut in a small hand wheel controlling a screw attached to the bearing of the small shaft, so that the operator can feel and observe the strain as he gradually applies it.

The third system of mechanism is that used for weighing the strains.

This consists of a frame or table supported on levers with knife-edge fulcrums, in principle substantially like those of a platform scale. Upon this table, the entablature containing the upper draw-head is supported by four columns. The levers for supporting the table and upper

draw-head are connected, by an intermediate lever and links having knife-edged bearings throughout, to a graduated beam, upon which a poise slides outwardly from the fulcrum as it is propelled by a screw supported in a parallel position on the beam, and turned by means of an endless cord that passes to the screw-propelling wheel in a vertical plane coincident with the balancing knife-edge. The engagement and disengagement of the screw-driving wheel with the screw are controlled by an electro-magnet having helices in circuit with electrodes, one of which is located on the outer end of the beam, and the other above it, so that whenever the beam rises, the circuit is closed and the poises on the beam moved further from the fulcrum. Then as further stress is applied, if the beam again rises, the poise is moved still further from the fulcrum, increasing the stress.

The rate of the progressive motion of the poise upon the beam is made variable and adjustable by means of a series of intermediate friction wheels through which the endless band receives motion. The first of this series of wheels receives a uniform motion from an endless band or cord passing around a grooved pulley turning with one of the driving pulleys in the driving shaft of the stress mech anism.

The motion of the pulley is transmitted by a slightly conical plate wheel embraced elastically between a pair of plate wheels having an adjustable arbor. The opposite side of the pair of plate wheels embraces another single, slightly conical, plate wheel turning the grooved wheel driving the endless cord leading to the screw-propelling pulley. The rate of motion of the cord and screw-driving pulley is less when the propelling plate wheel engages at its smaller diameter with the pair of plate wheels and when the opposite side of the pair of plate wheels engages the larger diameter of the driven plate wheel, and is greatest when the greater diameter of the driving plate wheel engages the pair of plate wheels, whilst the opposite edges of the pair of plate wheels engage the smaller diameter of the driven plate wheel. The fulcrum of the pair of plate wheels being adjustable as to position between the driving and driven

conical plate wheels, any desired intermediate rate of progression in weighing is readily procured.

The fourth system of mechanism embodied in this machine is that for measuring changes of form and recording the same, together with the stress upon the specimen at each and every instant of change.

This consists in a pair of clamps or divided collars which are secured by pointed set screws elastically held upon the specimen at definite initial distances, and calipers resting upon these collars, which, by means of an intervening mechanism, rotate a diagram-sheet holding cylinder, exactly in proportion to the differences in the motion of the opposite caliper jaws, and a pencil resting upon and marking the diagram sheet, travelling in the direction of the axis of the cylinder, in exact ratio with the motion of the poise upon the beam.

This portion of the mechanism is so novel and dissimilar from preceding inventions for the purpose as to require more exact and detailed description.

The clamps are two frames of metal having a pointed set screw and an opposite pointed plunger in line with and pressed toward the point of the set screw by a helical spring. A plate, fitting with mortises over tenons in the ends of the open sides of the clamp, serves to close it and support an adjustable block held by a thumb screw through a slot in the plate, which block, resting against the specimen, prevents any undue rocking of the clamp upon the points of the set screw and pointed plunger.

A pair of saddles mounted adjustably as to distance upon a parallel-sided bar and provided with seats to receive the lower sides of the clamps, serves to gauge them as to distance when placing the specimen in them; and in conjunction with each saddle, there is a set of rotatable gauges resembling eccentric polygonal prisms, which, by being turned to proper adjustment, support the specimen so that the plunger point and screw point lie in the same plane as the central axis of the specimen.

This apparatus for adjusting the clamps or collars upon the specimen is, of course, a distinct and separate implement

from the machine, but being an extremely useful, if not indispensable, adjunct, should be described with it.

The specimen with the clamps upon it is placed with its ends between the jaws in the draw-heads of the machine and the jaws tightened upon it by hand levers. Under the upper collar and above the lower collar, the fingers of a forked pair of calipers are placed. The fingers of the calipers are connected by pivots, and can be spread to adapt them to different widths of specimens and have an intermediate fulcrum upon which they can rock and adapt themselves to any inclination of the clamps.

One pair of caliper fingers is attached to an arm having a connected cord, which, after passing around a pulley in a lever, passes in a vertical plane coincident with the balancing axis of the beam, and is attached to a small winding barrel, secured to and turning the diagram-sheet bearing drum. The other pair of caliper fingers is connected by a link to the opposite end of the lever, and the arms of the lever are of such proportionate length to each other that the cord wound upon the barrel of the diagram-sheet holding drum is only moved to an extent proportioned to the difference between the motion of the caliper fingers. A slight spring in the winding barrel serves to wind the cord on the barrel and yields to the unwinding operation of the cord.

The pencil for marking the diagrams is moved by a connected nut engaged in the threads of a screw turned with the screw which operates the poise on the beam, so that the line marked on the paper indicates, by its ordinates, the stress at each moment noted by the line, and by the abscissæ, the extent of elongation between the points of attachment of the clamps.

In conjunction with the diagram-sheet holding cylinder there is an index, connected by a motion-multiplying device of sector and pinion, by which the elongation of the specimen is displayed upon a graduated sector or dial.

The fifth mechanism in this machine is an alarm or signal, by which, whenever the weighing beam oscillates beyond its normal extent of motion, a contact between an

electrode placed upon the beam and another placed above it, at greater distance than that controlling the poise motion, closes the circuit of an electric alarm bell and directs attention to the operation of the machine. This enables the operator when testing specimens cautiously and with slow applications of stress, to give attention to other work and yet witness every change of importance that might otherwise escape observation.

By removing the gripping jaws from the lower draw-head and placing supports in the table beneath it, and a block to transmit pressure from the draw-head to specimens laid upon the supports, the transverse strength or resistance to compression of specimens can be tested, and by introducing a mechanism between the draw-head for converting the right line of motion of the lever draw-head into curvilinear movement, the properties of materials under torsional strain can be tested, observed and recorded.

The combined effect of the several mechanisms is to enable the operator, with rapidity and certainty, to submit specimens to the action of the machine under conditions favorable for comparison of results, and to secure a graphic record of all the phenomena of change of form and variations in stress which occur at every stage of the test, to suit different dimensions of specimens and different rates of application of force to any required extent, and when desired, to closely feel the effect of the stress upon the specimen through the frictional gear with a delicacy of working, facility of observation and accuracy of record never before attempted.

This machine is the subject of United States letters-patent to Mr. Tinius Olsen, dated March 25, 1879 (No. 213,586); June 1, 1880 (No. 228,214); March 12, 1889 (No. 399,549) and January 27, 1891 (No. 445,476).

Following is an extract from the report of the Committee on Science and the Arts on the Olsen testing machine, to-wit:

"The committee recognizes that the increased complexity of this machine over others requires a more careful handling. They have not sufficient experience to say whether a greater number of tests can be made in a given

time than with other machines, but their opinion is that this testing method is a long step forward toward making such machines thorough instruments of precision, and it introduces instead of the numerical, the graphic record, the advantages of which are universally admitted.

"In view of the great ingenuity displayed by the inventor in arranging the several parts of the machine, notably in the mechanism which produces a graphic record of the test, similar to the indicator of a steam engine, and thus brings to perception at a single glance the variation in the strain of a number of specimens as well as the work required to break such specimens, the award of the Elliott Cresson medal is recommended."

GEORGE A. KOENIG, *Chairman.*
H. W. SPANGLER,
H. R. HEYL,
L. D'AURIA,
JOHN L. GILL, JR.

Adopted December 3, 1890.

H. W. SPANGLER,
Chairman of the Committee on Science and the Arts.

ELECTRICITY: ITS PAST, PRESENT AND FUTURE.

BY RALPH W. POPE,
Secretary American Institute of Electrical Engineers.

[*A lecture delivered before the Franklin Institute, December 16, 1889.*]

[*Concluded from p. 30.*]

It is not my purpose to trace the disputed ownership of the various inventions which serve to make up the modern systems of electric lighting. Probably every inventor who had given the subject any attention whatever, decided at once that the arc lamp was unsuitable for general interior lighting. The illuminating qualities of the arc lamp are due to the passage of the electric current from one carbon point to another. After the current begins to flow, these carbon points are separated and maintained at a uniform distance of about one-eighth of an inch by suitable

mechanism. The carbon pencils are slowly consumed by the action of the current, and it is necessary to renew them daily. The intense brilliancy of the arc lamp, its tendency to fluctuate, the hissing sound made by many of them, the high pressure of current generally used, are all objectionable features, when it is considered for domestic use. On the other hand, the incandescent lamp, as now made and used, is, without doubt, our most perfect artificial light. The heating property of electricity is utilized in this lamp, and the filament through which the current passes may be formed of different substances which, by patient investigation and experiment, have been found most suitable for the purpose. The metal platinum, which was first tried, has been replaced by carbon made from bamboo, silk fibre and other organic materials. In order to prevent the immediate combustion of the filament, it is fixed in a glass bulb, from which the air has been exhausted. Notwithstanding this precaution, however, the filament gradually deteriorates, and the average life of the lamp is limited to about 1,200 hours. With a perfect installation of incandescent lamps, there will be no fluctuation in the amount of light disseminated. There is a large and growing demand for lighting of this character, but unfortunately the necessity of power to drive a dynamo or the use of chemicals for generating electricity, prevents the extended use of the incandescent lamp among the masses. Its absolute safety, its healthfulness, its convenience, all point to its desirability for domestic use, but the high cost of its production restricts its enjoyment to a very small proportion of the people, while a large number of those who would gladly use it and willingly pay for it must wait patiently for the further development of the business. It is to be regretted that business competition, while stimulating the growth of the electric lighting business, has also brought it into disrepute by reason of the needless and entirely avoidable dangers which are supposed to be the necessary accompaniments of electrical distribution. The earlier electric lighting companies were apparently organized for speculative purposes. New York being the largest city in the country was the field naturally

selected for the exploitation of arc lighting on an extensive scale. The pioneer lines were constructed in the cheapest possible manner. It was soon ascertained by the insurance companies that the electric current used was liable to cause fires, and a system of inspection was organized by the Board of Underwriters, which had the authority to enforce it, as insurance of buildings was refused unless the installation conformed to the official standard of the board. Up to this time the wires had been covered with a cotton braid saturated with paraffine, under the supposition that they were thus insulated. A short exposure to weather soon removed this delusion, while it was found that the covering, upon being ignited, burned like a candle, the fire following the wire, thus increasing the risk of extensive conflagrations. This difficulty was obviated by the substitution of white lead paint for paraffine. This covering was fireproof and cheap. These were the only merits it possessed, but they were sufficient. It became known as "underwriters' wire," and following the lead of New York city, it has been extensively introduced in every important city and village in the country. It was soon discovered, however, that when water-soaked, the current would leak through this cotton covering wherever a contact was made that led to the ground, and at such points fires would be started, or that if a human being came in contact with the wire in such a manner as to become a path for the current, he was extremely liable to injury or death. The continual deterioration of these lines by exposure to weather, and the lack of attention given to their repair, led to the loss of so many lives that Superintendent I. N. Miller, of the Western Union Telegraph Company, suggested the name of "undertakers' wire," by which the description of wire approved by the Board of Underwriters is now generally known. It is unjust, however, to attribute all accidents to the use of this material. Had lines been properly constructed, and care taken to prevent accidental contacts, the record of deaths would not have been sufficiently large to have justified interference with the business on the part of the authorities. There is no such mystery about the action of electricity as is popularly supposed. We

provide a path over which it should travel, and if we make proper use of our scientific knowledge and engineering skill, the current may readily be confined to its prescribed limits. In the construction of lines, however, the electrical engineer has too frequently been ignored, and cheapness, rather than perfection, has been the end sought by those who are responsible for the management of most of these enterprises.

The use of electricity as a motive-power was investigated by some of our earlier inventors, as soon as the peculiar properties of the electro-magnet became known. It is true that the production of electricity by the chemical battery was a fatal obstacle to the commercial success of the electric motor in competition with the steam engine, but it was some time before the fallacy was entirely removed. Toy electric railways were exhibited throughout the country, and in 1837, Thomas Davenport, a village blacksmith of Brandon, Vt., operated a printing press by an electric motor, which like many of the electric inventions was really in advance of its time.

On April 29, 1851, Prof. Charles Grafton Page made a trial trip of his electro-magnetic locomotive, between Washington and Bladensburg, attaining a speed of nineteen miles per hour. An important improvement in electric motors was made by Pacinotti, in 1860, and although described in 1864, attracted but little attention at that time, as no sufficiently economical method of generating electricity had yet been discovered. This important feature existed, however, in the very machine which he had invented, and he subsequently pointed out that his principle was reversible, and that the motor might be used as a mechanical current generator. The advent of the dynamo machine in 1870, was followed by the practical demonstration in 1873, at the Vienna Exhibition, that a similar machine could be driven at a distance by simply connecting it into the circuit, and thus what is known as the reversibility of the dynamo, led up to the present activity in the field of electric power transmission and distribution. The most important branch of this field, and the most conspicuous, because it is brought directly to the

attention of the people, is the application of electricity to street railways. Those who are most interested in electrical progress are inclined to be impatient at what they believe is the tardy appreciation of the merits of electric traction. As a matter of fact electric railways have probably been introduced much more rapidly than was altogether prudent, when we consider the crude manner in which the work has been done in many cases, for it must be borne in mind that in the early stages of the development of a rival system, any failure is immediately utilized as an argument against the claims of the newcomer. We are all familiar with the manner in which accidents by electricity are reported throughout the land, and even cabled to Europe. Every effort will be used to remove the possibility of danger, and within ten years the electric motor will be as firmly established in our midst as the steam engine is to-day. Had it not been for the apparent danger from the boiler, the steam engine would probably have made its advent fifty years earlier, and civilization would have been correspondingly advanced. In 1769, as we learn from a German work, a locomotive for use on common roads was run in the streets of Paris by its inventor, but although it proved successful as a motor, it was unfortunate in its experience, for upon its first trial it punched a hole through a wall, and on its second it was upset and burst, and we can well imagine the alarm of the public at the idea of such a monster running amuck through the streets. Every day in the week, New York city is continually traversed by 300 high-pressure locomotives carrying steam at (say) 140 pounds to the square inch. The streets of our large cities are undermined with boilers for heating and power purposes. The Juggernaut of civilization slays at grade crossings in New Jersey, an average of a human being every forty-eight hours. Yet none of us would favor the abolition of the locomotive. Our country owes its prosperity to improved transportation. The modern steam railroad, however, perfect as we may consider it, does not supply all our needs. It must be supplemented by the horse car, the stage, the private vehicle and even the bicycle. Although our land seems gridironed with glistening rails, yet there are,

even in our most thickly settled states, large tracts of territory that are practically without adequate facilities for transportation. This is a field which we have reason to believe will soon be occupied by the electric railway. The progress already made has proved, that with proper engineering such a road can be operated with safety, efficiency and economy. The increased speed and superior service are so apparent, that its advantages to the public have already neutralized the prejudice existing against overhead wires, in the city of Boston. The result will soon be, that instead of rapid transit being confined to four main thoroughfares as is now the case in New York city, almost the entire street railway system will be operated at a higher speed than prevails on the New York elevated railroads to-day, and without the disadvantage of requiring passengers to ascend and descend long flights of stairs. Instead of facilitating improvements of this character, however, we find that our largest cities are adopting a policy of repression rather than regulation, the natural consequence of which is that those cities of secondary importance are in this respect taking the lead, the city of Scranton, for instance, having already entirely abolished animal-power and substituted the electric motor on all its lines.

The transmission and distribution of power by electricity for industrial purposes is, however, an exceedingly important field in which the electric motor is rapidly winning favor. It is natural that it should first be utilized for the service where its advantages are of the greatest importance and most attractive to the capitalist, and its adoption for street railway purposes has been followed very closely by its introduction in mining work, where its development has been retarded by attention being concentrated to other fields, rather than through any lack of appreciation on the part of mine owners. One of the most notable installations of this character is that at the Nevada mill, Virginia City, Nev., where the waste water from the turbine wheels at the surface is led through a vertical shaft 1,630 feet to a subterranean chamber driving six Pelton water wheels attached directly to the shafts of six dynamos, which are driven at

the rate of 900 revolutions per minute. The electric current thus generated is led back to the surface, and by means of six electric motors, the energy formerly wasted or utilized to little purpose, is made to perform service at the mill equal to 450 horse-power. So tremendous is the pressure of water at 1,630 feet head that the stream of water, as it issues from the nozzle, resists the blow of a hammer as in striking upon a bar of iron or steel. The waste water from the wheels is led off through the Sutro tunnel. It will be seen that in this case one of the most important advantages of electrical transmission is that the copper conductor can be carried through a shaft, utilizing but little space and making any desired bends or angles. It is, of course, important that the wires should be well insulated and located with proper care to avoid mechanical injury. A similar service has also been performed with rope transmission, but it is apparent to all who have given the subject attention, that the advantages of electricity will eventually be fully recognized. Indeed, it is to-day merely a matter of comparative cost. With the reduction of the manufacturing cost of motors, the lower cost of copper when artificial conditions are removed which now enhance its price, the use of high-pressure currents, where necessary, are all factors in the future utilization of electricity, which may be looked for with reasonable certainty within a very few years. It is in the distribution of power for small users, however, that the great public is most immediately interested. Almost every household may utilize light motors for various purposes. The only obstacle existing to-day to the installation of thousands of such motors, for fans, sewing-machines, pumps and similar work, is the difficulty of obtaining the electric current. Whether the possibility of obtaining power for light manufacturing will lead to the re-establishment of the little shops of early days, as has been predicted, appears somewhat problematical. The tendency of the times toward the concentration of craftsmen in large shops, is not because, altogether, of the difficulty of obtaining power, but is due rather to various well-known economies in manufacturing on a large scale, which have been

forced by the stress of competition. We should look upon electricity, not as in itself a force, but as the means of conveying that force for our benefit to any required point. There can be no more faithful agent. It is our own fault if we fail to provide the proper path over which it is to travel in our service. We know its requirements, and its laws are perfectly understood. Water, steam, gas, in fact, all our useful and familiar applications of nature's forces, must be treated in accordance with well-known laws, else in their might they will destroy us. We have become so familiar by long usage with the manifestations of nature's power, that we can scarcely realize the awe with which they must have been looked upon by the primeval inhabitants of the earth. One of the great thinkers of the day, Henry George, in arguing upon his favorite topic, "The Land Question," says:

"When, lit by lightning flash or friction among dry grasses, the consuming flames of fire first flung their lurid glow into the face of man, how he must have started back in affright! When he first stood by the shores of the sea, how its waves must have said to him, 'thus far shalt thou go, but no farther!' Yet, as he learned to use them, fire became his most useful servant, the sea his easiest highway. The most destructive element of which we know —that which for ages and ages seemed the very thunderbolt of the angry gods—is, as we are now beginning to learn, fraught for us with untold powers of usefulness. Already it enables us to annihilate space in our messages, to illuminate the night with new suns, and its uses are only beginning."

But what of the future? This is the era of prophecies as to the future of electricity, and many active minds are striving for the fortune that awaits the inventor of an economical process, for the production of electricity from coal without the wasteful intervention of steam. But even then, the crudity of the process does not commend itself, as the final solution of this great problem. If in the coal is stored the energy of the sun as expended on this planet thousands of years ago, why should we go on for years,

patiently blasting and digging out this wonderful mineral, slowly hauling it, hoisting it, screening it, bringing it again hundreds of miles by railway, and finally wasting a large share of its stored energy in our efforts to produce heat by combustion? After all this wasteful expenditure of energy in bringing this coal to our door, the best we can do to-day is to utilize from ten to fifteen per cent. of the force which has been secreted by nature for our use. Assuming as we must that the supply of coal will eventually be exhausted, our efforts would more properly be directed towards the utilization of force as supplied by nature at first hands. Whatever may be the financial outcome of our efforts in penetrating nature's secrets, we cannot go far astray if we look upon electricity as the agency of power. It appears to be nature's tool for placing her forces at our disposal. The very fact that it delivers energy instantaneously, in either of its practical forms of light, heat, or power, points out to us the perfect manner in which it has been adapted to our use. Science is not yet satisfied, however, with the conditions under which the light is now given to us. Nothing less than perfect light without heat or combustion—the secret of the phosphorescent rays of the glow-worm—will meet the advanced ideas of our modern investigators. Such a light may be perfected without the use of electricity, unless we accept the modern dictum, and which grows stronger as evidence accumulates, that light and electricity are the same. The distribution of heat through the agency of electricity, although not yet before the public as a practical system, is receiving much attention at the hands of ingenious inventors, who, it is evident, consider the subject of sufficient promise to warrant the devotion to it of time and money. To-day the most important applications of heat from the electric current are in the welding of metals, and the extraction of the wonderful metal aluminium through the medium of the electric furnace, both of which processes have already been brought to your attention in previous lectures, and I desire here to congratulate the worthy managers of this institute, its members and the community, for their successful efforts in encouraging progress, and

to thank them for the opportunities thus afforded for making known to the world the most recent developments in science and the arts for the benefit of the human family.

Although we marvel at the rapid strides recently made in electric development, we are inclined to be impatient at opposition encountered in the efforts made to extend the introduction of electric light and power. We should content ourselves with the reflection that this is but the ever-present inertia, which must be overcome before any stationary body can be moved. There exists in every community a conservative element, which has manifested itself in the past, and being a matter of record the present generation can well afford to laugh at the fears of our ancestors. I will cite a few instances which will do much toward reconciling us to the views of those who are to-day skeptical as to the benefits of electricity, or are sounding the alarm as to the dangers which must necessarily attend its general use.

In an article, entitled "How our Ancestors Travelled," we find the following pertinent observations on the subject:

"Carriages met with great opposition at their first introduction, and laws were made to suppress their use. As early as the year 1294, Philip the Fair, of France, issued an ordinance for suppressing luxury, in which the wives of citizens were forbidden the use of carriages. Beckmann tells us that there is preserved in the archives of the County of Mark, an edict, in which the feudal nobility and vassals are prohibited from using coaches under pain of incurring the punishment of felony. Duke John, of Brunswick, published an order in 1588, roundly rating his vassals for neglect of horsemanship, and forbidding them to appear or travel in coaches. A few years after this, the English Parliament took up the discussion of the subject; but, on the 7th of November, 1601, the bill to restrain the excessive use of coaches within the realm of England was rejected." But the bitterness of antagonism to them did not cease with this legislative decision. In a pamphlet, called the "Great Concern of England Explained," published 1673, the writer very gravely attempts to make out that the introduction of coaches was ruining the trade of the realm.

Following is an example of his method of reasoning: "Before coaches were set up, travellers rode on horseback, and men had boots, spurs, saddles, bridles, saddle-cloths, and good riding-suits, coats and cloaks, stockings and hats, whereby the wood and leather of the kingdom were consumed. Besides, most gentlemen, when they travelled on horseback, used to ride with swords, belts, pistols, holsters, portmanteaus and hat cases, for which in these coaches they have little or no occasion. For when they rode on horseback, they rode in one suit, and carried another to wear when they came to their journey's end; but in coaches they ride in a silk suit, silk stockings, beaver hats, etc., and carry no other with them. This is because they escape the wet and dirt, which upon horseback they cannot avoid; whereas, in two or three journeys on horseback these clothes and hats were wont to be spoiled; which done they were forced to have new very often, and that increased the consumption of manufactures." In another part of his pamphlet, the same writer puts the following query, evidently with the notion that it was a clincher: "Is it for a man's health or business to be laid fast in four ways; to ride all day with strangers, oftentimes sick, diseased, ancient persons, or young children crying; all whose humors he is obliged to put up with, and crippled with their boxes and bundles?" As an additional objection against the introduction of coaches, the writer urges that they would discourage the breeding and lessen the value of horses.

The following passage occurs in a protest against the construction of railways, which is preserved in the archives of the Nurnberg Railway at Furth, which was the first line constructed in Germany. It was drawn up by the Royal College of Bavarian Doctors:

"Travel in carriages drawn by a locomotive ought to be forbidden in the interest of public health. The rapid movement cannot fail to produce among the passengers the mental affection known as *delirium furiotum*. Even if travellers are willing to incur this risk, the Government should at least protect the public. A single glance at a locomotive passing rapidly is sufficient to cause the same cerebral

derangement, consequently, it is absolutely necessary to build a fence ten feet in height on each side of the railway."

These were all European, however, so in order to assure you that these peculiar views were held in our country, the following protest from the good citizens of Philadelphia, in 1833, against the introduction of gas, will be of interest to you:

PHILADELPHIA, November 28, 1833.

REMONSTRANCE AGAINST LIGHTING WITH GAS.

To the Honorable, the Select and Common Councils of the City of Philadelphia:

GENTLEMEN:—The subscribers beg leave to respectfully remonstrate against the plan now in action for *lighting the city with gas*, as they consider it a most offensive, inexpedient and dangerous mode of lighting. In saying this they are fully sustained by the accounts of explosions, loss of life and destruction of property where this mode of lighting has been adopted.

We consider gas to be as combustible as gunpowder and nearly as fatal in its acts; as regards the immense destruction of property, we believe that the vast number of fires in New York and other cities may be in a great measure ascribed to this mode of lighting. The leakage of pipes and carelessness of stopping off the gas furnish almost daily instances of its destructive effects. And when we consider that this *powerful and destructive agent* must necessarily be left often to the care and attention of youth and domestics and careless people, we only wonder that the consequences are not more *appalling*. It is also an uncertain light, sometimes suddenly disappearing and leaving streets and houses in total darkness.

The waters of the Delaware and Schuylkill, now considered the most pure and salubrious in the world, as many long voyages have fully tested, must soon, we fear, experience the deterioration which has reduced the water of the Thames to the present impure state, for no reservoir will be able to contain such fetid drains from such an establish-

ment, and very soon the rivers must be their receptacle, to the destruction of the immense shoals of shad, herring and other fish with which they abound; the same cause must produce the same effect. Salmon, smelts and other fish, formerly caught in vast quantities in the Thames, have nearly all disappeared. The constant digging up of the streets, the circumstances of the gas pipes, which, at the intersection of each square, must come in contact with the water pipes, are difficulties and evils which we would anxiously avoid.

In conclusion, we earnestly solicit that the *lighting our city with oil may be continued.*

And your petitioners, etc.

Signed by *1,200* of the leading citizens of Philadelphia, whose names are attached hereto, such as Horace Binney, Hartman Kuhn, Jacob Ridgway, Paul Beck, Henry Pratt, Benjamin Chew (on whose farm the battle of Germantown was fought), John Sargeant, Charles Wharton, Richard Willing, Edward Pennington, Robert Vaux, Joshua Longstreth, Matthew Newkirk, and 1,200 others.

N. B.—The above are only part of the names, as many of the remonstrances have not yet come in.

It is not best that the exploitation of a new industry should be too rapid. Improvements are continually being brought out, which render the devices of yesterday entirely obsolete. What we ask is that the merits of electricity for the various purposes for which we claim it is adapted, should be thoroughly investigated, that the exaggerated statements as to its dangers be carefully analyzed, and I would especially recommend that every mechanic, every business manager, every man concerned in the development of great enterprises should devote a little of his time to the study of electricity. Opportunities may present themselves at any moment where the use of electricity will prove important and beneficial. It is a duty we owe to ourselves and the community to make the best possible use of the resources placed in our hands. This is the age of mechanical progress. Year by year the hand of man is being more and

more superseded by the machine. For fifty years we have witnessed the material progress of an era of steam and iron. We are entering upon an age of electricity and aluminium. Let us unite in welcoming these accessions to human welfare, that the glory of the twentieth century may even surpass that which will soon pass into history. The nineteenth century has witnessed the triumphant development of the great principle established by Alessandro Volta in 1800—that electricity had entered submissively into the control of man—and with the exercise of skill and intelligence in his control, it will remain until the dawn of the millennium, for it is the edict of nature that it shall prevail until the end.

I am indebted to the researches of my esteemed friend, Thomas D. Lockwood, for the dates of the following interesting events in electrical history:

1729.

July 3.—Electrical insulation discovered by Stephen Gray.

1747.

July 14.—Electricity passed through a wire across the Thames over Westminster bridge, the circuit being completed through the water.

1752.

July 4.—Benjamin Franklin demonstrated the identity between lightning and electricity by flying a kite during a thunder-storm.

1753.

Feb. 1.—First suggestion of the electric telegraph, in a communication signed C. M. in *Scott's Magazine.*

1800.

Mar. 20.—Alessandro Volta announced his invention of the voltaic pile.

April 30.—Nicholson and Carlisle discover the principle of electro-chemical deposition.

Sept. 22.—Spark from voltaic battery, as observed by Davy, announced in *Nicholson's Journal.*

Oct. 24.—First telegraph patent taken out in the United States by Jonathan Grout.

1820.

July 21.—Oersted's discovery of electro-magnetism first announced.

Sept. 15.—The invention of the galvanometer announced by Schweigger.

Sept. 25.—Arago announced before the French academy his discovery that a copper wire energized by electricity became magnetic.

1827.

Oct. 10.—Joseph Henry announces his invention of a practical electro-magnet.

1831.

Aug. 27.—An electric current from a permanent magnet developed by Faraday.

Oct. 1.—Faraday produced a current in one circuit by induction from a current flowing in another. First in Great Britain,

1832.

Mar. 30.—Magneto-electric spark first obtained from permanent magnet by Prof. Forbes, Edinburgh, Scotland. It appears that the document giving an account of the excitation of a spark from a permanent magnet, is by Signor Nobili, and another dated from the Museum at Florence, January 31, 1832.—*Noad, 1859.*

Oct. 19.—Morse first conceived his idea of an electro-magnetic telegraph on board the ship *Sully*, between Havre and New York.

Dec. 15.—Faraday used the earth to complete a voltaic circuit by means of water and gas pipes.

1836.

July 23.—Daniell announced the invention of his sulphate of copper constant battery.

June 24.—First patent in electro-metallurgy issued in England to G. R. Elkington.

Dec. 23.—Steinheil's telegraph first described in the *Magazine of Popular Science.*

1837.

June 6.—English patent for electromotor issued to Thomas Davenport, of Brandon, Vt.

July 25.—English needle telegraph first practically operated on a subterranean line between Easton and Camden Town.

Sept. 2.—Morse made his first experiment in telegraphy.

1839.

May 4.—The invention of electrotyping announced by Jacobi.

May 21.—Heat manifested by the transmission of electricity through suitable wires from the gymnotus or electric eel.

Nov. 2.—Electro-magnetic motor exhibited in England by Captain Taylor.

1840.

June 20.—Patent for electro-magnetic telegraph issued to Prof. Morse.

1841.

Aug. 21.—First patent describing the incandescent electric lamp issued in England to F. de Moleyns.

1842.

Aug. 1.—The use of the magneto-electric machine for electro-deposition suggested in a British patent taken out by J. S. Woolrich.

1844.

May 24.—First message sent over a telegraph wire by the Morse system.

1845.

April 1.—First American electric telegraph opened for business between Washington and Baltimore.

Nov. 4.—Incandescent carbon in a vacuum patented in England by Starr, in the name of E. A. King.

1846.

April 11.—Patent granted to Prof. Morse for his invention of the local circuit operated by a main line relay.

1849.

Jan. 10.—First experimental submarine cable laid by C. V. Walker, two miles out at sea from Folkestone, England.

1851.

Feb. 7.—Central office system patented by F. M. A. Dumont, in England.

April 29.—Prof. Charles G. Page makes an experimental trip in his electro-magnetic locomotive from Washington to Bladensburg and return, the highest speed being 19 miles per hour.

1858.

May 18.—First arc lamp patent issued in the United States.

Aug. 5.—The laying of the first Atlantic cable completed, which worked for 26 days.

Nov. 24.—Dynamo principle described in an English patent.

Dec. 8.—Electric light first employed in light-house work at South Foreland, England.

1859.

Sept. 20.—First patent granted in the United States for heating by electricity.

1866.

July 27.—Telegraph communication successfully and permanently established between Europe and America.

Dec. 24.—S. A. Varley provisionally patents in England the dynamo principle, first described and patented by Hjorth in 1854, and subsequently elaborated in an English patent of 1858.

1867.

Jan. 17.—Werner Siemens proposed the name dynamo machine in an address before the Berlin academy.

Feb. 14.—Sir Charles Wheatstone explains the dynamo principle before the Royal Society.

1873.

June 3.—The reversibility of the dynamo demonstrated by Hippolyte Fontaine.

1875.

June 2.—First form of the Bell telephone made.

1876.

Mar. 7.—Patent granted to Alexander Graham Bell for the telephone.

Mar. 23.—First patent granted to Jablochkoff for his electric candle.

1877.

April 4.—First telephone line completed between Boston and Somerville, Mass.

1880.

Jan. 27.—Patent granted to Thomas A. Edison for an electric incandescent lamp having a carbon filament of high resistance.

Oct. 20.—The mechanical formation of secondary battery plates patented in France by Camille Faure.

1886.

Aug. 10.—Electric welding patented by Prof. Elihu Thomson.

SOME PROPERTIES OF CONFOCAL ELLIPSES AND THEIR APPLICATION TO MECHANISM.

BY HORACE B. GALE,
Washington University, St. Louis.

In several books on mechanism a graphical method is described, by which confocal ellipses are made use of in constructing the pitch outlines of sets of lobed wheels having various numbers of lobes. In Rankine's *Machinery and Millwork*, the discovery of this method is attributed to the Reverend W. Holditch. No demonstration of the rolling properties of these wheels is there given, however, nor has any demonstration ever been published within the writer's knowledge.

The following is offered as a contribution to the science of mechanism, and as bringing out certain properties of confocal ellipses which are not set forth in existing works on analytical or descriptive geometry.

In *Fig. 1* are represented two semi-ellipses having the same foci, F_1 and F_2. About the common centre O are

drawn auxiliary circles, having radii equal respectively to the semi-major axes, OA_1, OA_2. Let OC_1C_2 represent any radial line cutting the circles in points C_1 and C_2, respectively. From any such pair of points let fall perpendiculars to the major axes, C_1D_1 and C_2D_2, cutting the ellipses in a pair of points, P_1 and P_2.

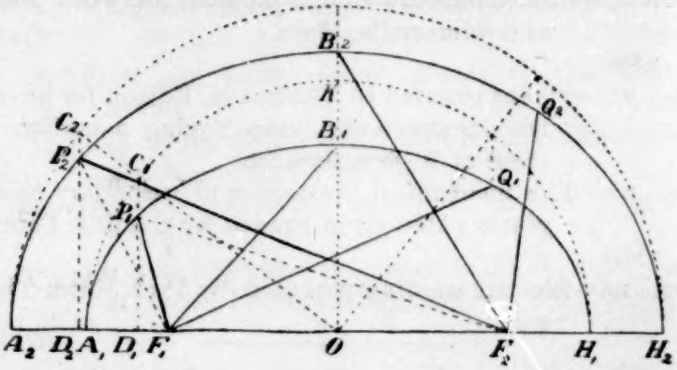

FIG. 1.

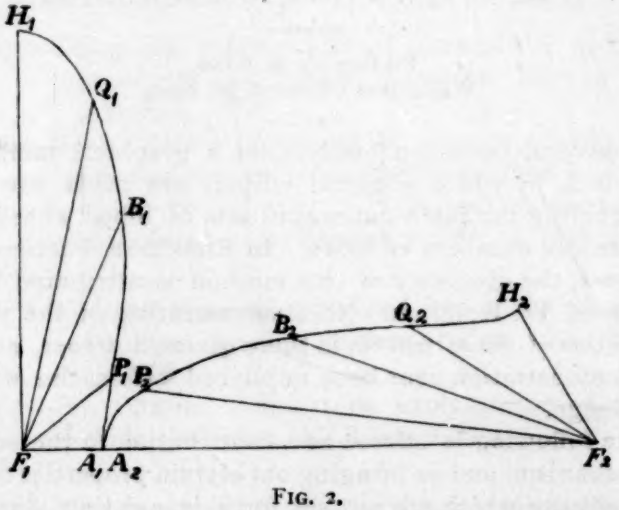

FIG. 2.

In *Fig. 2*, let F_1 and F_2 represent fixed centres about which a pair of sectors are to turn in rolling contact with each other, the distance F_1F_2 being equal to the sum of the semi-

major axes of the ellipses ($OA_1 + OA_2$); and let the focal distances of successive points on one of the ellipses, as F_1A_1, F_1P_1, F_1B_1, etc., be laid off in order on successive radial lines from the fixed centre F_1, while the focal distances of the corresponding points of the other ellipse, F_2A_2, F_2P_2, F_2B_2, etc., are similarly laid off from the centre F_2. Also let the angle between the focal lines drawn to each two successive points of the first ellipse, as the angles $A_1F_1P_1$, $P_1F_1B_1$, etc., be reduced, or *contracted*, in *Fig. 2* in any fixed ratio, $\frac{1}{n_1}$; and let the focal angles of the second ellipse, as $A_2F_2P_2$, $P_2F_2B_2$, etc., be contracted in *Fig. 2* in the ratio $\frac{1}{n_2}$; the numbers n_1 and n_2 being taken proportional to the lengths of the semi-minor axes of the corresponding ellipses, OB_1 and OB_2.

The proposition now to be proved is, that two sectors, constructed in the manner described, are capable of turning in perfect rolling contact about the fixed points F_1 and F_2, and that each pair of corresponding points of the two pitch lines, as P_1 and P_2, will coincide, as they come into the line of centres.

In order that any two non-circular sectors may turn about fixed centres in perfect rolling contact, the two following conditions must be fulfilled: (1) for each pair of corresponding points, as P_1 and P_2, the sum of the distances of the points from the respective centres, $F_1P_1 + F_2P_2$, must be equal to the distance between the centres; (2) at each point of either pitch line, as P_1, the *obliquity* must be the same as that of the other pitch line at the corresponding point, P_2. By the obliquity of the pitch line is meant the angle made by a tangent to the curve at a given point, and a tangent to a circle about the fixed centre or focus, at the same point; for example, the angle *MPN*, in *Fig. 3*. The condition usually stated for perfect rolling contact—that the distances between corresponding points, measured along the two pitch lines, must be equal—is included, at least for non-circular figures, in the statement just made, that the pitch lines must have equal obliquity at each pair of corresponding points.

It is, therefore, to be proved that in the sectors constructed

as described, the obliquity of the pitch line at any point P_1 (*Fig. 2*) is the same as the obliquity at the corresponding point P_2. Let us first refer to *Fig. 1*, and find the relation between the obliquity of the first ellipse at P_1 and that of the other at P_2.

Let a_1 and a_2 represent the semi-major axes, b_1 and b_2 the semi-minor axes, and e_1 and e_2 the eccentricities, of the two ellipses, respectively. Let o_1 represent one-half the angle $F_1P_1F_2$, and o_2 one-half the angle $F_1P_2F_2$. Then o_1, o_2—being each equal to the angle between a normal to the ellipse and a focal line—are respectively equal to the angles of obliquity of the two ellipses at P_1 and P_2. Let the centre O be taken as the origin, x_1 and y_1 as the coördinates of P_1, and x_2 and y_2 as the coördinates of P_2.

In analytical geometry (for example, see Todhunter's *Conic Sections*, p. 156, art. 178), is deduced the following general value for the tangent of the angle made by the normal and focal line at any point of an ellipse:

$$\tan o = \frac{e\,a\,y}{b^2}.$$

Applying this equation to the ellipses of *Fig. 1*, we have

$$\frac{\tan o_1}{\tan o_2} = \frac{e_1\,a_1\,y_1}{b_1^2} \quad \frac{b_2^2}{e_2\,a_2\,y_2}. \tag{1}$$

The eccentricity of an ellipse is the ratio of one-half the distance between the foci to the semi-major axis; therefore

$$e_1 = \frac{OF_1}{a_1},$$

$$e_2 = \frac{OF_1}{a_2},$$

and

$$e_1\,a_1 = e_2\,a_2 = OF_1. \tag{2}$$

We have also, from *Fig. 1*,

$$\frac{C_1D_1}{P_1D_1} = \frac{OK}{OB_1}.$$

or

$$\frac{C_1D_1}{y_1} = \frac{a_1}{b_1}. \tag{3}$$

Similarly,

$$\frac{C_2D_2}{y_2} = \frac{a_2}{b_2}. \tag{4}$$

Dividing (4) by (3), we have

$$\frac{C_2D_2}{y_2} \quad \frac{y_1}{C_1D_1} = \frac{a_2}{b_2} \quad \frac{b_1}{a_1};$$

but

$$\frac{C_2D_2}{C_1D_1} = \frac{OC_2}{OC_1} = \frac{a_2}{a_1};$$

therefore

$$\frac{y_1}{y_2} = \frac{b_1}{b_2}. \tag{5}$$

Substituting values from equations (2) and (5) in equation (1), and reducing the expression to its lowest terms, we have, for any pair of corresponding points, as P_1 and P_2, in confocal ellipses,

$$\frac{\tan o_1}{\tan o_2} = \frac{b_2}{b_1}. \tag{6}$$

This equation expresses the relation between the tangents of the angles of obliquity of the two ellipses at P_1 and P_2. It remains to determine the effect of contracting the angles between the focal lines, as is done in constructing the sectors in *Fig. 2*.

When the focal angles of any curve are contracted in a given proportion, the length of the radii remaining constant, the ratio of the angle between any two radii to the difference in length of those radii is reduced in the given proportion. The value of the differential coëfficient,

$$\frac{d\theta}{dr},$$

at any point in the contracted curve, is accordingly less

than the value at the corresponding point on the original one, in the ratio of contraction, $\frac{1}{n}$. (See *Fig. 3.*)

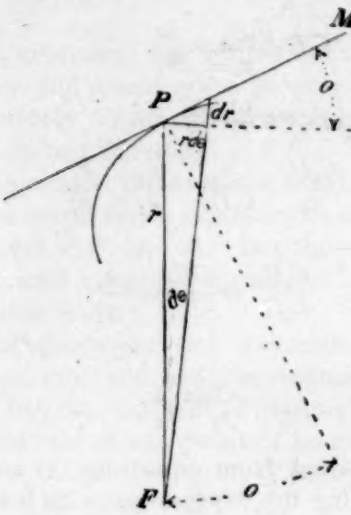

FIG. 3.

Therefore, at any point on the contracted curve,

$$\frac{dr}{d\theta},$$

has n times the value which it has at the corresponding point of the original curve.

Therefore, also,

$$\frac{dr}{r \cdot d\theta}$$

or the tangent of the obliquity at any point of the contracted curve, is n times as large as it is at the corresponding point of the original curve.

It follows that, on the two sectors derived by contracting the focal angles of the semi-ellipses, we shall have the tangents of the angles of obliquity at P_1 and P_2 (*Fig. 2*), equal, respectively, to $n_1 \tan o_1$ and $n_2 \tan o_2$: but as the values of n_1

and n_2 were taken proportional to the lengths of the semi-minor axes, we have

$$\frac{n_2}{n_1} = \frac{b_2}{b_1};$$

and substituting this value for $\frac{b_2}{b_1}$ in equation (6), we obtain

$$\frac{\tan o_1}{\tan o_2} = \frac{n_2}{n_1};$$

or,

$$n_1 \tan o_1 = n_2 \tan o_2.$$

Therefore, the obliquity of the pitch line of one of the sectors at any point P_1 is equal to the obliquity of that of the other at the corresponding point P_2.

If now it can be proved also that at every pair of corresponding points, as P_1 and P_2, the sum of the distances F_1P_1 and F_2P_2 is equal to the distance between the two fixed centres, or if, for every such pair of points on the ellipses,

$$F_1P_1 + F_2P_2 = a_1 + a_2,$$

then we know that the two sectors will work together in perfect rolling contact. In *Fig. 1*, we have

$$\overline{P_1F_1}^2 = (x_1 - OF_1)^2 + y_1^2, \tag{7}$$

$$\overline{P_2F_2}^2 = (x_2 + OF_1)^2 + y_2^2. \tag{8}$$

From (7),

$$\overline{P_1F_1}^2 = x_1^2 - 2\,\overline{OF_1}x_1 + \overline{OF_1}^2 + y_1^2. \tag{9}$$

Applying the equation of the ellipse, we have

$$\frac{x_1^2}{a_1^2} + \frac{y_1^2}{b_1^2} = 1;$$

or

$$y_1^2 = b_1^2 - \frac{b_1^2}{a_1^2}\,x_1^2.$$

Substituting this value for y_1^2 in (9), we have

$$\overline{P_1F_1}^2 = x_1^2 - 2\,\overline{OF_1}\,x_1 + \overline{OF_1}^2 + b_1^2 - \frac{b_1^2}{a_1^2}\,x_1^2;$$

or

$$\overline{P_1F_1}^2 = \frac{a_1^2 - b_1^2}{a_1^2} \quad x_1^2 - 2\,\overline{OF_1}\,x_1 + \overline{OF_1}^2 + b_1^2.$$

But

$$a_1^2 - b_1^2 = \overline{OF_1}^2;$$

therefore

$$\overline{P_1F_1}^2 = \frac{\overline{OF_1}^2}{a_1^2} x_1^2 - 2\,\overline{OF_1}\,x_1 + a_1^2 - b_1^2 + b_1^2;$$

or

$$P_1F_1 = a_1 - \frac{OF_1}{a_1} x_1. \qquad (10)$$

By a similar process we obtain from equation (8)

$$P_2F_2 = a_2 + \frac{OF_1}{a_2} x_2. \qquad (11)$$

Adding equations (10) and (11), we have

$$P_1F_1 + P_2F_2 = a_1 + a_2 + \left(\frac{x_2}{a_2} - \frac{x_1}{a_1}\right) OF_1.$$

But, from *Fig. 1*,

$$\frac{x_1}{a_1} = \frac{x_2}{a_2};$$

therefore

$$P_1F_1 + P_2F_2 = a_1 + a_2. \qquad Q.\ E.\ D.$$

The principles which have now been proved may readily be applied to the construction of the pitch lines of a set of interchangeable lobed wheels, having various numbers of lobes, any one of which is capable of working in rolling contact with any other, or with a given ellipse, which is itself a one-lobed wheel. *Fig. 5* shows the pitch lines of a pair of such wheels, having two and three lobes, respectively.

The angle included between the shortest and the longest radius of a lobe of a symmetrical wheel, whose whole num-

ber of lobes is n (for example, the angle DAC, in *Fig. 5*), must be

$$\frac{360°}{2n}, \text{ or } \frac{180°}{n}.$$

Now, if each half lobe is derived by the process of contracting the angles between the focal lines of a semi-ellipse—the angle between the shortest and the longest of those lines in the ellipse being 180°—the ratio in which the angles must be contracted for a wheel of n lobes will be evidently $\frac{1}{n}$. In other words, the ratio of contraction of the angles of the base ellipse, used in deriving the pitch line of a lobe of any wheel of the set, will be one divided by the number of lobes; and the ratios of contraction for different wheels of the set will be to each other inversely as their numbers of lobes. Put in order that the various lobes may work correctly together, the obliquity at corresponding points of their pitch lines must be the same; which, as has been shown, is true only when the ratios of contraction are inversely as the semi-minor axes of the base ellipses. It follows that the minor axes of the base ellipses for a set of interchangeable lobed wheels must be proportional to the numbers of lobes of the corresponding wheels. The focal angles are then to be contracted to one-half the original value for a two-lobed wheel, one-third for a three-lobed wheel, and so on. For a one-lobed wheel, the ratio of contraction would be unity; in other words, the one-lobed wheel will be itself an ellipse equal to its base ellipse, arranged to turn about one of its foci.

The base ellipses for all the wheels of a set must therefore be constructed on the same foci as the ellipse forming the one-lobed wheel, and with minor axes equal respectively to the minor axis of the one-lobed wheel, multiplied by the number of lobes. The outlines of the lobes of the various wheels are then constructed by contracting the angles of each base ellipse in the ratio of the reciprocal of the number of lobes. Any wheel of such a set will work correctly with any other, or with another wheel like itself. It follows that any ellipse will work in rolling contact with an equal

ellipse, when each is made to turn about one of its foci, the distance between the centres of rotation being equal to the major axis.

It is evident, also, that by making use of any part of the arc of a single ellipse (as A_2P_2, in *Fig. 1*) subtending different

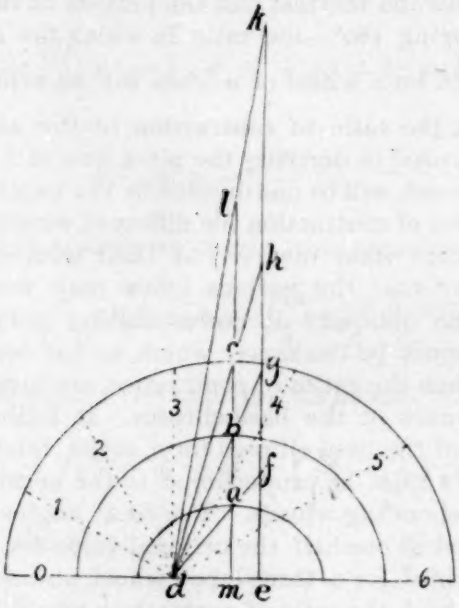

FIG. 4.

angles at the two foci, and contracting or expanding these angles in the *same* ratio, pairs of sectors may be derived which will work correctly with each other, and turn through any desired angles. Moreover, if the angles subtended by these sectors are made any aliquot parts of 180°, they may be used as the half lobes of symmetrical lobed wheels. Again, by combining about a common centre sectors derived from elliptical arcs having different foci, each working with a sector derived from the same arc, or from a corresponding arc of a confocal ellipse, an infinite variety of non-symmetrical lobed wheels may be formed. Such lobed wheels may also be formed by combining arcs derived from ellipses with

logarithmic spirals, or suitable irregular curves, each paired with a suitable corresponding arc.

A number of special methods of applying these general principles are well set forth in Prof. C. W. MacCord's treatise

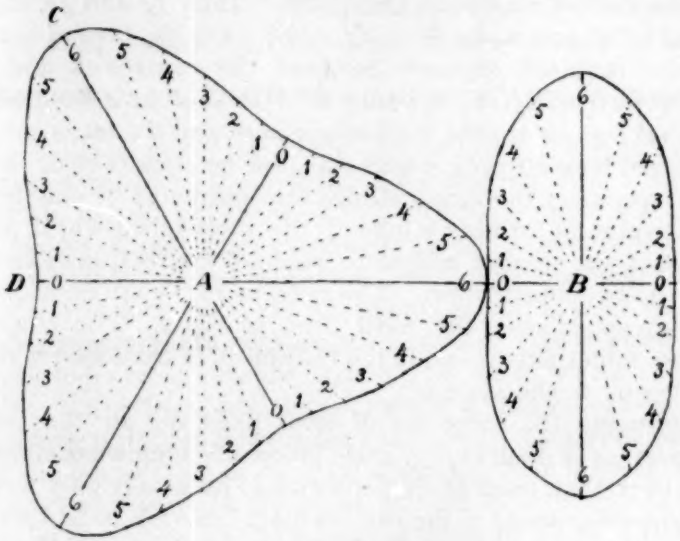

FIG. 5.

upon the *Kinematics of Mechanical Movements*, Part I. Other special problems of interest are treated in Rankine's *Machinery and Mill Work*. One other point will be noticed in this article, viz.: the formation of non-circular wheels whose outlines are to have *a definite maximum obliquity*.

The maximum obliquity of the pitch line of any one of a set of interchangeable lobed wheels must be the same as that of the one-lobed wheel belonging to the set; and the maximum obliquity of an ellipse—corresponding to the maximum value of the angle o, in *Fig.* 1—will be at a point in the curve situated at the end of the minor axis. The obliquity at that point will be equal to the angle between the minor axis and a focal line. The following is given as an example of a special application of these principles.

Let it be required to construct the pitch lines for a two-lobed wheel and a three-lobed wheel to turn in rolling con-

tact about the centres *A* and *B*, situated at a fixed distance apart, the maximum obliquity of the pitch lines to be 40°. In *Fig. 4*, first lay off the right angle *def*, and from any convenient point *d* draw *df*, making $edf = 50°$ (the complement of the desired maximum obliquity). Take *fg* and *gh*, each equal to *ef*, and make $dk = dg + dh$. On *dk*, take *dl* equal to the required distance between the centres *A* and *B*. Draw *lm* parallel to *ke*; then $db + dc = dl = AB$; therefore *mb* and *mc* are the semi-minor axes, and *d* a focus of the required base ellipses, which may now be constructed. The focal angles of the larger ellipse are contracted to one-third their value in forming a lobe of the three-lobed wheel, and those of the smaller ellipse to one-half their value in forming the two-lobed wheel. The radii in *Fig. 5* are numbered to correspond with the focal lines in *Fig. 4*. The ellipse, whose minor axis is *ma*, is the outline of a one-lobed wheel belonging to the same set.

By using the same set of focal lines for all the base ellipses, as is done in *Fig. 4*, the process is somewhat simplified over that used in *Fig. 1*, which is necessary only when *corresponding points* in the various pitch lines are to be found. The method of deriving the lobed wheels from the ellipses, illustrated by *Figs. 4* and *5*, is the one which is usually given in books on mechanism, but of which no demonstration has heretofore been published. That part of the construction of *Fig 4*, fixing the maximum obliquity and the distance between the centres of the lobed wheels, and the method of finding corresponding points, illustrated by *Figs. 1* and *2*, are believed to be now published for the first time.

HIGH EXPLOSIVES IN WARFARE.

By Commander F. M. Barber, U. S. N.

[*A lecture delivered before the Franklin Institute, November 28, 1890.*]

Members of the Institute and Ladies and Gentlemen:

In commencing my paper this evening I desire to call your attention to the fact that I am dealing with a subject which, though not theoretical, is still hardly practical, for as a matter of fact, high explosives cannot be said to have yet been regularly used in warfare, and I hope you will pardon me if in consequence, my statements appear in some respects unsatisfactory and my theories unsound. My subject, however, is no more obscure than future naval warfare generally. All civilized nations are spending millions of money for fighting purposes directly in opposition to the higher feelings of the better class of their inhabitants. The political atmosphere of Europe is the cause of this, but its consequence is the development of theoretical plans of ships which are no sooner commenced than the rapid march of mechanical, chemical and electrical science shows them to be faulty in some particular feature, and others are laid down only to be superseded in their turn.

None of these crafts are obsolete (to use the popular expression of the day). All are theoretically better than any which have stood the test of battle; but each excels its predecessor in some particular feature. The use of high explosives is the direct cause of the very latest transformations in marine architecture, and is destined to work still greater changes; but it will require a war between the most civilized nations of the world, and a long war to either confirm or condemn the many theoretical machines and methods of destruction that modern science has produced. I say a war between the most civilized nations, since it is only they that can supply the educated intellect that is necessary to both attack and defence. Under other circumstances false conclusions as to

weapons and results are certain to be drawn. At the bombardment of Alexandria, the English armor-clads, with their rifled guns, were not nearly as efficient against the feeble chalk fortifications as our wooden ships would have been with smooth bore guns; on the other hand I saw on shore after the bombardment hundreds of torpedoes and miles of cable that the Egyptians did not understand how to use. The French war with China was equally unsatisfactory from a military point of view. The Chinese at Foochow were annihilated because the French opened fire first, and the only shell that penetrated a French iron-clad was filled with lampblack instead of powder. The national riots that we are accustomed to hear of in South America are likewise of little instructive value; they buy their weapons of more civilized people, but there is always something fatally defective about the tactics pursued in using them. It may be said in general terms that in these days of extreme power in fighting machines, the greater the efficiency the less the simplicity and the more knowledge required in the care of the weapons. When powder was merely powder the advice of the old adage to "trust in God and keep your powder dry" was ample to maintain the efficiency of the powder for all purposes; but nowadays, if you keep your powder dry you will burst your gun, and if you keep your gun-cotton dry you are liable to blow up your ship.

It is rather difficult to-day to define what high explosives are, in contradistinction to gunpowder. Thirty years ago we could say that powder was a mechanical mixture and the others were chemical compounds; but of late years this difference has disappeared.

The dynamical difference, however, still remains; gunpowder in its most efficient form is a slow-burning composition, which exerts a relatively low pressure and continues it for a long time and to a great distance; high explosives on the contrary, in their most efficient form, are extremely quick-burning substances, which exert an enormous pressure within a limited radius. Ordinary black gunpowder consists of a mechanical mixture of seventy-five per cent. of saltpetre, fifteen per cent. of charcoal and ten per cent.

of sulphur. The most important of the high explosives are formed by the action of nitric acid upon organic substances or other hydrocarbons, the compound radical NO_2 being substituted for a portion of the hydrogen in the substance. The bodies thus formed are in a condition of unstable equilibrium; but if well made from good material, they become stable in their instability, very much like Prince Rupert's drops, those little glass pellets which endure almost any amount of rough usage; but once cracked, fly into infinitesimal fragments.

The power exerted by these nitro substitution products is due to the fact that they detonate, *i. e.*, they are instantaneously converted into colorless gas at a very high temperature, and in addition, they have almost no solid residue, Nitro-glycerine actually leaves none at all, while gunpowder leaves sixty-eight per cent. The first departure in gunpowder from the old-time constituents of black powder just mentioned, was for the purpose of obtaining less pressure and slower combustion than could be produced by mere granulating or caking; this was accomplished by using underburned charcoal together with sugar and about one and one-half per cent. of water. This is the brown powder most generally used at present and with satisfactory results; but the abstraction of its moisture increases its rapidity of combustion to a dangerous degree, besides which the underburned charcoal is itself unstable.

The next change demanded is smokelessness and to accomplish it, recourse is had to the high explosive field, mechanically mixing various substances with them to reduce and regulate their rapidity of action. Just now some form of gun-cotton is most in use mixed with nitrate of ammonia, camphor and other articles. The tendency of these mixtures is to absorb moisture, and the gun-cotton in them to decompose, and there is no smokeless powder which can to-day be considered successful. Such a powder, however, will undoubtedly be an accomplished fact in the near future. Military men seem to be a great deal at variance as to its value in the field but there can be no doubt of its value for naval purposes; it is a necessity

forced upon us by the development of torpedo warfare. First came the simple torpedo, at the end of an ordinary boat's spar; then came the special torpedo boat with its great speed; then the revolving cannon and rapid fire gun to meet the torpedo boat. At present the possible rapidity of fire is much greater than can be utilized on account of the smoke; hence the necessity of smokeless powder. Smokelessness is, however, principally a martial demand that has been made upon the science of explosives and has attracted public attention on that account. The commercial demands for various other properties has been much greater than the military, and between gunpowder near one end of the line in point of power and nitro-glycerine near the other, there are now over 350 different explosives manufactured, and most of these have been invented within the last twenty years.

The simplest application of high explosives in warfare is in connection with torpedoes, since within the same bulk a much more efficient substance can be obtained than gunpowder and with reasonable care there is very little danger of premature explosions by reason of accidental shocks.

Torpedoes were made by the Chinese many years ago; they were tried in our war of independence, and also by the Russians during the Crimean war; but the first practical and successful use of them as a recognized weapon was during our war of secession, when thirty-seven vessels were either sunk or seriously injured by them. Gunpowder was used in these torpedoes, though it is stated that attempts were made to use other substances without success. Since that time all maritime nations have made a close study of the subject and have adopted various high explosives, according to the results of their experiments. In general terms it may be stated that explosive chemical compounds have been found more suitable than explosive mixtures, because of the uniformity of direction in which they exert their pressure, and from the fact that water does not injure them. Mixtures may be very powerful but they are erratic and require tight cases. In the United States we use dynamite for harbor mines. It is composed of seventy-five

per cent. nitro-glycerine and twenty-five per cent. silica; but blasting gelatine and forcite gelatine will probably be adopted, when they can be satisfactorily manufactured here, as they are more powerful. The former is composed of ninety-two per cent. of nitro-glycerine and eight per cent. of gun-cotton, and the latter of ninety-five per cent. of nitro-gelatine and 5 per cent. unnitrated cellulose.

For naval use we have adopted gun-cotton as being the most convenient. In Europe gun-cotton is generally used for both fixed mines and movable torpedoes; Russia, Austria and Italy use blasting gelatine also.

In actual warfare but little experience has been had; two Peruvian vessels were sunk by dynamite in the Chile-Peruvian war; one Turk by means of gun-cotton during the Turco-Russian war of 1877, and two Chinese by gun-cotton in the Franco-Chinese war of 1884.

In making experiments to determine the relative strength of the different explosives under water, very curious and puzzling results have been obtained. Nitro-glycerine being the simplest and most complete in its chemical decomposition, and apparently the most powerful in air, it was natural to suppose that it would be the same in submarine work; but it was found by Gen. Abbot at Willet's Point after repeated experiments, as shown in his report of 1881, that it was not so powerful in its effect by twenty per cent. as dynamite No. 1, although the dynamite contained twenty-five per cent. of an absolutely inert substance. His idea was that it was too quick in its action, and since water is slightly compressible, a minute fraction of time is required in the development of the full force of the explosive. Gen. Abbot's results for intensity of action per unit of weight of the most important substances, is as follows:

Blasting gelatine,	142
Forcite gelatine,	133
Dynamite No. 1,	100
Gun-cotton, wet,	87
Nitro-glycerine,	81
Gunpowder,	20 to 50

Col. Bucknill, of the Royal Engineers, in his publication of 1888, gives the following:

Blasting gelatine,	142
Forcite gelatine,	133
Dynamite No. 1,	100
Gun-cotton, dry,	100
Gun-cotton, wet,	80
Gunpowder,	25

In both tables dynamite No. 1 is assumed as the standard of comparison. Col. Bucknill states that his gun-cotton results differ from Gen. Abbot's, because he experimented with much larger quantities, viz: 500-pound charges. Gen. Abbot's experiments led him to believe that an instantaneous mean pressure of 6,500 pounds per square inch would give a fatal blow to the double bottom of a modern armor-clad, and he developed a formula which gives this blow with blasting gelatine at the following distances under water, viz:

	Pounds.
At 5 feet,	4
10 "	17
20 "	67
30 "	160
40 "	311

Col. Bucknill's experiments caused him to believe that a pressure of 12,000 pounds per square inch is required, and his formula, which is somewhat different from Abbot's, gives widely different results at close quarters, but they approach each other as the distance increases.

His results are as follows:

	Pounds.
At 5 feet,	23½
10 "	75
20 "	177
30 "	274
40 "	369

Regarding the comparative effects of gunpowder and the high explosives, I think Gen. Abbot's estimate of a varying value for powder is more admissible than the fixed value assigned by Col. Bucknill. Gunpowder gives a

push and detonating compounds a shock; as the quantities increase, the push reaches farther than the shock. According to Gen. Abbot 100 pounds of dynamite No. 1 will have a destructive horizontal range of 16·3 feet, while the same amount of gunpowder will only have a range of 3·3 feet. Five hundred pounds of dynamite, however, will have a horizontal range of thirty-five feet, and 500 pounds of gunpowder will have 19·5 feet; the ratio has diminished from five to two. Whether 6,500 pounds or 12,000 pounds per square inch is necessary to crush the bottom of an armor-clad will depend largely upon how far apart the frames of the ship are spaced and what other bracing is supplied, as well as many local circumstances. It is difficult to judge exactly of these matters. Some four years ago, the Italian Government adopted treble bottoms for their heaviest ships as a result of experiments with seventy-five pounds of gun-cotton (the charge of an ordinary Whitehead locomotive torpedo) against a caisson which was a fac-simile of a portion of the proposed ships. Only two of the bottoms were broken through, and when the space between the two inner bottoms was filled with coal, only the outer bottom was broken. According to the formulæ of either Abbot or Bucknill, there should have been a local pressure of at least 300,000 pounds per square inch on the outer skin, and yet judicious interior arrangements rendered it harmless to the target. It would not, however, be safe to conclude that the torpedo was thus vanquished—the immediate result was simply to create a demand for larger locomotive torpedoes for local application, and but little light was thrown upon the results which might be anticipated from a large mine at a greater distance, whose radius of explosive effect would embrace a larger portion of the ship, and especially if the ship were nearly over the torpedo. The local effect of a detonation is different from the transmitted shock. Experiments in England have shown that 500 pounds of gun-cotton at forty feet below any ship will sink her, and at a horizontal distance of 100 feet, damage to the interior pipes and machinery is to be expected.

The fact that the high explosives are so much heavier

than gunpowder has an important bearing on the size of the containing case. Their sp. gr. is as follows:

Nitro-glycerine,	1·6
Blasting gelatine,	1·45
Forcite gelatine,	1·51
Dynamite No. 1,	1·6
Wet gun-cotton,	1·32
Dry gun-cotton,	1·06
Gunpowder,	0·9

Their relative efficiency under water per cubic foot, according to Bucknill, is as follows:

Blasting gelatine,	1·38
Forcite gelatine,	1·27
Dynamite No. 1,	1·00
Dry gun-cotton,	·66
Wet gun-cotton,	·66
Gunpowder,	·14

The wet gun-cotton has twenty-five per cent. of added water.

Mines for harbor defence are of two kinds—buoyant and ground. The buoyant are usually spherical, and contain from 400 to 500 pounds of explosive. They bring the charge near to the ship's bottom, but are difficult to manage in a tide-way, and can be easily found by dragging. The ground mines can be made of any size and are not easily found by dragging, but are of little value in very deep water. They are either cylindrical, or hemispherical in shape, and contain from 500 to 1,500 pounds of explosive in from thirty to eighty feet of water. Mines of any kind are exceedingly difficult to render efficient when the water is over 100 feet deep. On account of the tendency of all high explosives to detonate by influence or sympathy and the liability of the cases to collapse by great exterior pressure, harbor mines are separated a certain distance, according as they are buoyant or ground, and according to the nature of the explosive.

Five hundred pounds buoyant gun-cotton mines require 320 feet spacing.

Five hundred pounds buoyant blasting gelatine mines require 450 feet spacing.

Six hundred pounds ground gun-cotton mines require 180 feet spacing.

Six hundred pounds ground blasting gelatine mines require 230 feet spacing.

Of torpedoes, other than those described, we have several modern varieties; submarine projectiles, submarine rockets, automobile and controllable locomotive torpedoes. The two first varieties, though feasible, are not developed and have not yet advanced beyond the experimental stage. Of the automobile, we have the Whitehead, Swartzkopf and Howell. The first two are propelled by means of compressed air and an engine; the last by the stored-up energy of a heavy fly-wheel. Generally speaking, they are cigar-shaped crafts, from 10 to 18 feet long and 15 to 17 inches in diameter, capable of carrying from 75 to 250 pounds of explosive at a rate of 25 to 30 knots for 400 yards, at any depth at which they may be set. Of the controllable locomotive torpedoes, the three representative types are the Patrick, Sims and Brennan. They are in general terms cigar boats, about 40 feet long and 2 feet in diameter, carrying charges of 400 pounds of explosive. The Patrick and Sims are maintained at a constant depth under water by means of a float. The Brennan has diving rudders like a Whitehead or a Howell. The Patrick is driven by means of carbonic acid gas through an engine and is controlled by an electric wire from shore. The Sims is driven by electricity from a dynamo on shore through a cable to an electric engine in the torpedo. The Brennan is driven and controlled by means of two fine steel wires wound on reels in the torpedo, the reels being geared to the propeller shafts. The wires are led to corresponding reels on shore, and these are rapidly revolved by means of an engine. A brake on each shore reel controls the torpedo. The speed of all these torpedoes is about 19 knots, and their effective range one mile.

A Whitehead was successfully used in the Turco-Russian war of 1877. The Turkish vessel previously mentioned was sunk by one.

Blasting gelatine, dynamite and gun-cotton are capable of many applications to engineering purposes on shore in time of war, and in most cases they are better than powder. They received the serious attention of French engineers during the siege of Paris, and were employed in the various sorties, which were made from the city, in throwing down walls, bursting guns, etc. An explosive for such purposes, and indeed for most military uses, should satisfy the following conditions:

(1) Very shattering in its effects.
(2) Insensible to shocks of projectiles.
(3) Plastic.
(4) Easy and safe to manipulate.
(5) Easy to insert a fuze.
(6) Great stability at all natural temperatures and when used in wet localities.

Neither blasting gelatine, dynamite nor gun-cotton fulfil all these conditions; but they satisfy many of them and are more powerful than other substances. For the destruction of walls, trees, rails, bridges, etc., it is simply necessary to attach to them small bags of explosive, which are ignited by means of blasters' fuze and a cap of fulminate of mercury, or by an electric fuze.

We now come to the application of high explosives to warfare in the shape of bursting charges for shells. This is the latest phase of the problem and it is undoubtedly fraught with the most important consequences to both attack and defence. Difficult as it has been to obtain an exact estimate of the force of different explosives under water, the problem is far greater out of the water and under the ordinary conditions of shell fire; the principal obstacle being in the fact that it is physically impossible to control the force of large quantities in order to measure it, and small quantities give irregular results. Theoretically, the matter has been accomplished by Berthelot, the head of the French Government "Commission of Explosives," by calculating the volume of gas produced, heat developed, etc.; and this method is excellent for obtaining a fair idea of the specific pressure of any new explosive that may be brought

forward, and determining whether it is worth while to investigate it further; but the explosives differ so much from each other in point of sensitiveness, weight, physical condition, velocity of explosive wave, influence of temperature and humidity, that we cannot determine from mere theoretical considerations, all that we would like to know. Various methods of arriving at comparative values have been tried, but the figures are very variable, as will be seen by the following tables. Berthelot's commission, some ten years ago, exploded ten to thirty grams of each in 300 pound blocks of lead and measured the increased size of the hole thus made. The relative result was:

No. 1 dynamite,	1·
Dry gun-cotton,	1·17
Nitro-glycerine,	1·20

Powder blew out and could not be measured.

Mr. R. C. Williams, at the Boston Institute of Technology, in the winter of 1888 and 1889, tried the same method, but used six grams in forty-five pound blocks of lead. He obtained a relative result of—

No. 1 dynamite,	1·
Dry gun-cotton,	1·37
Nitro-glycerine,	2·51
Explosive gelatine,	2·57
Forcite gelatine,	2·7
Warm nitro-glycerine,	2·7
Gunpowder,	·1

The powder gave great trouble in this case, also, by blowing out.

M. Chalon, a French engineer, obtained some years ago, with a small mortar, firing a projectile of thirty kilos and using a charge of ten grams of each explosive, the following ranges:

	Metres.
Blasting-powder,	2·6
No. 1 dynamite,	31·4
Forcite of 75 per cent. N. G.,	43·6
Blasting gelatine,	45·

Roux and Sarrau obtained by experiments in bursting

small bomb shells the following comparative strengths of ranges:

Powder,	1·
Gun-cotton,	6·5
Nitro-glycerine,	10·0

In actual blasting work the results vary altogether with the nature of the material encountered, and with the result that is desired to be accomplished, viz: throwing out, shattering, or mere displacement.

Chalon gives for quarrying:

Powder,	1
Dynamite No. 2, containing 50 per cent. nitro-glycerine,	3

For open blasting:

Dynamite No. 3, containing 30 per cent. N. G.,	1·0
Dynamite No. 1, containing 75 per cent. N. G.,	2·5
Blasting gelatine,	3·5

For tunnelling:

Dynamite No. 3, containing 30 per cent. N. G.,	1
Dynamite No. 1, containing 75 per cent. N. G.,	3
Explosive gelatine,	19

Finally Berthelot's theoretical calculations give a specific pressure of—

Powder,	1
Dynamite,	13
Gun-cotton,	14
Nitro-glycerine,	16
Blasting gelatine,	17

It will be observed that the practical results vary largely from the theoretical values, but they seem to indicate that gun-cotton and No. 1 dynamite are very nearly equal to each other, and that in the nitro-glycerine compounds, except where gun-cotton is added, the force appears to be nearly in proportion to the nitro-glycerine contained. From the foregoing it seems fair to estimate roughly the values of bursting charges of shells as follows:

Powder,	1
Gun-cotton and dynamite,	6 to 10
Nitro-glycerine,	13 to 15
Blasting gelatine,	15 to 17

Attention has been turned in Europe for more than thirty years towards firing high explosives in shells; but it is only within very late years that results have been reached which are claimed as satisfactory, and it is exceedingly difficult to obtain reliable accounts even of these. Dynamite was fired in Sweden in 1867 in small quantities, and a few years later it was fired in France. But two difficulties soon presented themselves. If the quantity of nitro-glycerine in the dynamite was small, it could be fired in ordinary shells, but the effect was no better than with gunpowder. If the dynamite was stronger in nitro-glycerine, it took but a small quantity to burst the gun. As early as 1864, dry gun-cotton was safely fired in shells in small quantities, but when a sufficient quantity to fill the shell cavity was used, the gun burst. Some few years ago it was found that if the gun-cotton was either wet or soaked in paraffin, it could be fired with safety from powder guns in ordinary shells, provided the quantity was small in proportion to the total weight of the shell, (say) five to six per cent.; but a new difficulty arises from the fact that it breaks the shell up into very small pieces, and it is an unsettled question among artillerists whether more damage is done to an enemy by breaking a shell into comparatively large pieces and dispersing them a long distance with a bursting charge of powder, which has a propulsive force, or by breaking it with a detonating compound into fine pieces, which are not driven nearly so far. When used against troops there is also the objection to the high explosive shell, that it makes scarcely any smoke in bursting, and smoke at this point is useful to the artillerist in rectifying his aim. In the matter of shells for piercing armor, however, there are no two opinions regarding the nature of the bursting charge. To pierce modern armor at all a shell must be made of forged steel, so thick that the capacity of the cavity for the bursting charge is reduced to one-fourth or one-fifth of what it is in the common shell; the result is that a charge of powder is frequently not powerful enough to burst the shell at all; it simply blows the plug out of the filling hole in the rear. In addition it is found that in passing through armor, the heat generated is

so great that the powder is prematurely ignited. If then we can fill the small cavity in the shell with an explosive which will not ignite prematurely, and yet will burst the shell properly after it has passed through the armor, the problem will be solved. Wet or paraffined gun-cotton can be made sluggish enough to satisfy the first condition; but at present the difficulty is to make it explode at all. The more sluggish the gun-cotton, the more powerful must be the fuze exploders to detonate it, and such exploders are themselves liable to premature ignition in passing through the armor. The Italians and Germans claim to have accomplished the desired result up to a thickness of five inches of armor; gun-cotton and fuze both working well. But the English authorities say that no one has yet accomplished it. The Austrians claim to have succeeded in this direction within the last year with a new explosive called ecrastite (supposed to be blasting gelatine combined with sulphate or hydrochlorate of ammonia, and claimed to be one and one-half times as powerful as dynamite). With a gun of 8·24-inch calibre and an armor-piercing shell, weighing 206·6 pounds, containing a bursting charge of 15·88 pounds of ecrastite, they are said to have perforated two plates four inches thick, and entered a third four-inch plate where the shell exploded. There is a weak point in this account in the fact that the powder capacity of the shell is said to be 4·4 pounds. This amount is approximately correct, judging from our own eight-inch armor-piercing shell, but if this is true there could not have been more than nine pounds of ecrastite in the shell instead of sixteen, or else there is an exceedingly small proportion of blasting gelatine in ecrastite, and if that is the case it is not one and one-half times as powerful as dynamite. If it is weak stuff it is probably insensitive, and even if it were strong, one swallow does not make a summer. The English fired quantities of blasting gelatine from a two-inch Nordenfeldt gun in 1884, but when they tried it in a seven-inch gun in 1885, they burst the gun at once. I have only analyzed this Austrian case, because the statement is taken from this year's annual report of the Office of Naval Intelligence, which is an excellent authority, and to illustrate the fact that of the thousands of

accounts, which we see in foreign and domestic newspapers, concerning the successful use of high explosives in shells, fully ninety per cent. are totally unreliable In many cases they are in the nature of a prospectus from the inventors of explosives or methods of firing, who are aware of the fact that it is almost impossible to dispute any statements that they may choose to make regarding the power of their new compounds, and thinking, as most of them do, that power alone is required.

Referring to the qualities that I have previously cited as being required in a high explosive for military purposes, it is sooner or later found that nearly all the novelties proposed lack some of the essentials and soon disappear from the advertising world only to be succeeded by others. The most common defect is lack of keeping qualities. They will either absorb moisture or will evaporate; or further chemical action will go on among the constituents, making them dangerously sensitive or completely inert, or they will separate mechanically according to their specific gravities.

For further clearness on the subject of the shell charges, which have so far been discussed, the following table is added of weight and sizes of shells for U. S. naval guns, with their bursting charges of powder:

6-inch	com.	cast-steel	shell	3½ to 4	cal. long,	wt.	100	lbs., charge	6 lbs.
8 "	"	"	"	"	"		250	"	14½ "
10 "	"	"	"	"	"		500	"	27 "
12 "	"	"	"	"	"		850	"	45 "

ARMOR-PIERCING FORGED STEEL SHELL.

6-inch,	3	calibres	long,	weight	100	lbs., charge	1½	lbs.
8 "	"	"		250	"		3	"
10 "	"	"		500	"		5½	"
12 "	"	"		850	"		11	"

The chief efficiency of small quantities of high explosives having reduced itself to the case of armor-piercing projectiles, it next became evident that there was an entirely new field for high explosives into which powder had entered but little, and this was the introduction of huge torpedo shells which did not rely for their efficiency upon the dispersion

of the pieces of the shell, but upon the devastating force of the bursting charge itself upon everything within the radius of its explosive effect. It is in this field that we may look for the most remarkable results, and it is here that the absolute power of the explosive thrown is of the utmost importance, provided that it can be safely used. Attention was at once turned in Europe to the manufacture of large projectiles with great capacity for bursting charges and it has resulted in the production of a class of shells 4½ to 6 calibres long, with walls only ·4 of an inch thick. (If they are made thinner they will swell and jam in the gun when fired.)

These shells are used in long guns up to 6 and 8½ inches calibre and in mortars up to 11·2 inch. They are made from discs of steel, 3 to 4 feet in diameter and 1 inch thick, and are forced into shape by hydraulic presses. The base is usually screwed in, but some of the German shell are made in two halves which screw together. The Italians were the first in this new field of investigation, but the Germans soon followed and after trying various materials were at length reasonably successful with gun-cotton soaked in paraffin. Their 8·4 inch mortar shells of 5 calibres contain 42 pounds; those of 6 calibres contain 57 pounds; and the 11·2 inch mortar shells of 5 calibres contains 110 pounds.

The projectile velocity used with the mortars is about 800 f. s. The effect of these shells against ordinary masonry and earth fortifications is very great. The charge of forty-two pounds has broken through a masonry vault of three feet, four inches thick, covered with two feet, eight inches of cement and with three to five feet of earth over all. The shell containing fifty-seven pounds, at a range of two and one-half miles, broke through a similar vault covered with ten feet of earth; but with seventeen feet of earth the vault resisted. In 1883, experiments at Kummersdorf showed that a shell containing the fifty-seven pound charge would excavate in sand a crater sixteen feet in diameter and eight feet deep with a capacity of twenty-two cubic yards. The Italians have had similar experiences; but it is notable that

in both Germany and Italy several guns and mortars have burst. The velocity in the guns is not believed to exceed 1,200 to 1,300 f. s., and it is not thought that the quantity of gun-cotton is as great in the gun shells as in the mortars. I have lately been informed on good authority that the use of gun-cotton shells has been abandoned in the German navy as too dangerous.

The French, in their investigations in this field, found gun-cotton too inconvenient, and decided upon melenite. This substance has probably attracted more attention in the military world than all others combined, on account of the fabulous qualities that have been ascribed to it. Its composition was for a long time entirely a secret; but it is now thought to consist principally of picric acid, which is formed by the action of nitric acid upon phenol or phenyillic alcohol, a constituent of coal tar. The actual nature of melenite is not positively known, as the French Government, after buying it from the inventor, Turpin, are said to have added other articles and improved it. This is probable, since French experiments in firing against a partially armored vessel, the *Bellequense*, developed an enormous destructive effect, while the English, who afterwards bought it, conducted similar experiments against the *Resistance* and obtained no better results than with powder. The proof that the *Bellequense* experiments were deemed of great value by the French, lies in the fact that they immediately laid down a frigate—*Dupuy de Lome*—in which four-inch armor is used, not only on the side, but about the gun stations, to protect the men; this thickness having been found sufficient to keep out melenite shell. In most armor-clads, the armor is very heavy about the vitals, but the guns are frequently much exposed.

The best authenticated composition for melenite consists of picric acid, gun-cotton and gum-arabic, and lately it is stated that the French have added cresilite to it. Cresilite is another product of coal tar. Melenite is normally only three times as strong as gunpowder; but it is said to owe its destructive qualities in shells to the powerful character of the exploder which ignites it. It has been

known for some years that all explosives (including gunpowder), are capable of two orders of explosion according as they are merely ignited or excited by a weak fuze or as they are powerfully shocked by a more vigorous excitant. Fulminate of mercury has been found most serviceable for the latter purpose. With melenite the French have reproduced all the results that the Germans have effected with gun-cotton and have found that a shell containing 119 pounds of it will penetrate nearly ten feet of solid cement, but will not penetrate armored turrets six to eight inches thick. The French claim that melenite has an advantage over gun-cotton in not being so dangerous to handle and being insensible to shock or friction, and they have obtained a velocity of 1,300 f. s. with the 8·8 inch mortar and claim to have obtained 2,000 f. s. in long guns up to 6·2 inch calibre. However this may be, they are known to have had severe accidents at the manufactory at Belfort and at least one 5·6 inch gun was burst at the *Bellequense* experiments in firing a sixty-six pound shell containing twenty-eight pounds of melenite. The French are said to have large quantities of melenite shells in store, but they are not issued to service.

Probably one reason why we have so many conflicting yet positive accounts of great successes in Europe with torpedo shells, is because each nation wishes its neighbors to think that it is prepared for all eventualities, and they are obliged to keep on hand large quantities of some explosive, whether they have confidence in it or not. Fortunately we are not so situated; but singularly enough what we have done in the field of high explosive projection has been accomplished by private enterprise, and we have attacked the problem at exactly the opposite point from which European nations have undertaken it. While they have assumed that the powder gun with its powerful and relatively irregular pressures was a necessity and have endeavored to modify the explosive to suit it, we have taken the explosive as we have found it, and have adapted the gun to the explosive. At present the prominent weapon in this new field is the pneumatic gun, but it is obvious

that steam, carbonic acid gas, ammonia or any other moderate and regulatable pressure can be used as well as compressed air; it is merely a question of mechanical convenience. In throwing small quantities of certain high explosives, powder guns can be used satisfactorily, but when large quantities are required, the mechanical system of guns possess numerous advantages. All the high explosives are subject to premature detonation by shock; each of them is supposed to have its own peculiar shock to which it is sensitive; but what this shock may be is at present unknown. We do know, however, that premature explosions in guns are more liable to occur when the charge in the shell is large than when it is small; this is due to the fact that when the gun is fired, the inertia of the charge in the shell is overcome by a pressure proportional to the mass and acceleration, which pressure is communicated to the shell charge by the rear surface of the cavity and the pressure per unit of mass will vary inversely as this surface. If then the quantity of explosive in the shell forms a large proportion of the total weight of the shell, we approach in powder guns a condition of shock to it which is always dangerous and frequently fatal. The pressure behind the projectile varies from twelve to fifteen tons per square inch, but it is liable to rise to seventeen and eighteen tons, and in the present state of the manufacture of gunpowder we cannot in ordinary guns regulate it nearer than that. It is not a matter of so much importance so far as the guns are concerned, when using ordinary projectiles, as the gun will endure a pressure of from twenty-five to thirty tons per square inch; but with high explosives in the shell it is a vitally serious matter. From all I can learn regarding European practice, it appears that not only are the explosives made sluggish, but the quantity seldom exceeds thirty per cent. of the weight of the shell and the velocities, notwithstanding, are kept very low. In the pneumatic gun the velocity is low also, but so is the pressure in the gun. The pressure in the firing reservoir is kept at the relatively low figure of 1,000 pounds per square inch or less, and the air is admitted to the chamber of the gun by a balance valve

which cuts off just the quantity of air (within a very few pounds) that is required to make the shot. The gun is long and advantage is taken of the expansion of the air. In no case can the pressure rise in the gun beyond that in the reservoir.

Up to the present time there have been no accidents in using the most powerful explosives in their natural state, and in quantities over fifty per cent. of the weight of the projectile. I have seen projectiles weighing 950 pounds, and containing 500 pounds of explosives (300 pounds of the blasting gelatine and 200 pounds of No. 1 dynamite) thrown nearly a mile and exploded after disappearing under water. According to Gen. Abbot's formula such a projectile would have sunk any armor-clad floating within forty-seven feet of where it struck. Apparently there is no limit to the percentage of explosive that can be placed in the shell except the mechanical one of having the walls thick enough to prevent being crushed by the shock of discharge. In the large projectiles a transverse diaphragm is introduced to strengthen the walls and to subdivide the charge.

The development of the pneumatic gun has been attended with some other important discoveries which may be of interest. It is well known that mortar fire is very inaccurate, except at fixed long distances, in consequence of the high angle, the slowness of flight of the projectile, the variability of the powder pressure, and the inability to change the elevation and the charge of powder rapidly. In the pneumatic gun, the complete control of the pressure remedies the most important of the mortar's defects and makes the fire accurate from long ranges down to within a few yards of the gun. It is obvious that the pressure can be usefully controlled in two ways: (1) by keeping the elevation of the gun fixed and using a valve that can be set to cut off any quantity of air according to the range desired; (2) by keeping the pressure in the reservoir constant, and using a valve which will cut off the same quantity of air every time, changing the elevation of the gun according to the distance. Another important discovery consists in the application of subcalibered projectiles for obtaining increased

range. The gun is smooth bored and a full-sized projectile is a cylinder with hemispherical ends, to the rear of which is attached a shaft having metal vanes placed at an angle, which cause the projectile to revolve round its longer axis during flight. A subcalibered projectile, however, being of less diameter than the bore of the gun, has the vanes on its exterior, and is held in the axis of the gun by means of gas checks which drop off as the projectile leaves the muzzle. The shock to the explosive is, of course, greater than in the full-sized projectile, but the increase can be calculated, and so far a dangerous limit has not been reached. From the fifteen-inch gun, with a pressure of 1,000 pounds per square inch, and a velocity of about 800 f. s., a range of 4,000 yards has been obtained at an elevation of 30° 20, with a ten-inch subcalibered projectile, about eight calibres long and weighing 500 pounds. This projectile will contain 220 pounds of blasting gelatine. With improved full-sized projectiles weighing 1,000 pounds, a range of 2,500 yards will doubtless be obtained. At elevations below 15° these long projectiles are liable to ricochet and what is now wanted is a projectile which will stay under water at all angles of fall and will run parallel to the surface like a locomotive torpedo. Such a projectile has yet to be invented; but I have seen a linked shell which has been experimented with from a nine-inch powder gun, that partially meets this condition. It is made of several sections united by means of rope or electric wire in lengths of 100 or 150 feet. When fired, all sections remain together for some distance; the rear section then first begins to separate; then the next, and so on. It is primarily intended to envelope an enemy's vessel, and to remedy the present uncertainty of elevation in a gun mounted in a pitching boat; but it is found that when it strikes the water in its lengthened out condition, it will neither dive nor ricochet, but will continue for some distance just under the surface until all momentum is lost when it will sink. This projectile is at present crude, and has never been tried loaded, but it will probably be developed into something useful in time.

I have confined my remarks in the foregoing discussion principally to such methods of using high explosives in shells as have proved themselves successful beyond an experimental degree, and practically they reduce themselves to two, viz: using a sluggish explosive in small quantities from an ordinary powder gun, and using any explosive from a pneumatic or other mechanical gun. Naturally, the success of the latter method will soon induce the manufacture of powders having an abnormally low maximum pressure. There is undoubtedly a field for the use of such powders in connection with an air space in the gun to still further regulate the pressure; but nothing of this sort has yet been attempted. Many methods of padding the shell have been devised for reducing the shock in powder guns, but the variability of the powder pressure is too great to have yet rendered any such method successful. A method was patented by Gruson in Germany of filling a shell with the two harmless constituents of an explosive and having them unite and explode by means of a fulminate fuze on striking an object. He used for the constituents nitric acid and dinitro-benzine, and was quite successful; but the system has not met with favor on account of the inconvenience. The explosive was about four times as powerful as gunpowder.

That the advantage of using the most powerful explosives is a real one can be easily shown. The eight-inch pneumatic gun in New York harbor, with a projectile containing fifty pounds of blasting gelatine and five pounds of dynamite, easily sunk a schooner at 1,864 yards range from the torpedo effect of the shell falling alongside of it. This same shell, if filled with gunpowder, would have contained but twenty-five pounds, and have had but one-ninth the power.

The principal European nations are now building armored turrets sunk in enormous masses of cement, as a result of their experiences with gun-cotton and melenite. The fifteen-inch pneumatic projectile, which I described as being capable of sinking an armor-clad at forty-seven feet

from where it struck, would have been capable of penetrating fifty feet of cement had it struck upon a fortification. It was not only a much larger quantity of high explosive than Europeans have experimented with, but the explosive itself is probably more than twice as strong as their gun-cotton and five or six times as strong as their melenite. In the plans of Gen. Brialmont, one of the most eminent of European engineers, he allows in his fortifications about ten feet of cement over casements, magazines, etc. It is evident that this is insufficient for dynamite shells such as I have described.

At Fort Wagner, a sand work built during our war, Gen. Gilmore estimated that he threw one pound of metal for every 3·27 pounds of sand removed. He fired over 122,230 pounds of metal, and one night's work would have repaired the damage. The new fifteen-inch pneumatic shell will contain 600 pounds of blasting gelatine, and judging from the German experiments at Kummsdorf, which I have cited, one of these fifteen-inch shells would throw out a prodigious quantity of sand; either 500 pounds to one of shell, or 2,000 pounds to one of shell, according as the estimate of Gen. Abbot or of Capt. Zalinski is used. The former considers that the radius of destructive effect increases as the square root of the charge; the latter that the area of destructive effect for this kind of work is directly proportional to the charge.

The effect of the high explosives upon horizontal armor is very great; but we have yet to learn how to make it shatter vertical armor. No fact about high explosives is more curious than this, and there is no theory to account for it satisfactorily. As previously stated, the French have found that four inches of vertical armor is ample to keep out the largest melenite shells, and experiments at Annapolis, in 1884, showed that masses of dynamite No. 1, weighing from seventy-five to 100 pounds, could be detonated with impunity when hung against a vertical target composed of a dozen one-inch iron plates bolted together.

In conclusion, I may say that in this country we are prone to think that the perfection of the methods of throwing high

explosives in shell is vastly in favor of an unprotected nation like ourselves, because we could easily make it very uncomfortable for any vessels that might attempt to bombard our sea-coast cities.

This is true as far as it goes, but unfortunately the use of high explosives will not stop there. I lately had explained to me the details of a system which is certainly not impossible for damaging New York from the sea by means of dynamite balloons. The inventor simply proposed to take advantage of the sea-breeze which blows toward New York every summer's afternoon and evening. Without ever coming in sight of land, he could locate his vessel in such a position that his balloons would float directly over the city and let fall a ton or two of dynamite by means of a clockwork attachment. The inventor had all the minor details very plausibly worked out, such as locating by means of pilot balloons the air currents at the proper height for the large balloons, automatic arrangements for keeping the balloon at the proper height after it was let go from the vessel, and so on. His scheme is nothing but the idea of the drifting or current torpedo, which was so popular during our war, transferred to the upper air. An automatic flying machine would be one step farther than this inventor's idea, and would be an exact parallel in the air to the much dreaded locomotive water torpedo of to-day. There seems to be no limit to the possibilities of high explosives when intelligently applied to the warfare of the future, and the advantage will always be on the side of the nation that is best prepared to use them.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated meeting, held at the institute, Tuesday, January 20, 1891.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 20, 1891.

Dr. Wm. H. Wahl, president, in the chair.

Members present: Prof. E. F. Smith, Prof. L. B. Hall, Mr. George L. Norris, Dr. Geo. A. Koenig, Dr. E. H. Keiser, Dr. D. K. Tuttle, Dr. S. C. Hooker, Mr. Lee K. Frankel, Mr. H. Pemberton, Jr., Mr. Henry Bower, Mr. W. H. Bower, Mr. L. E. Williams, Prof. Henry Trimble, Mr. A. A. Moore.

The annual report of the treasurer was read and approved.

The resignation of Mr. C. V. Petraeus was received and accepted.

The report of Mr. H. Pemberton, Jr., as chairman of the committee of conference of the Chemical Section, appointed to confer with a similar committee of the American Chemical Society, was read and accepted. This committee was appointed by the president a few days after the last meeting of the section in December, and in response to a request for such a committee from Mr. A. A. Breneman, chairman of the committee of arrangements of the American Chemical Society.

The object of this conference was to consider, in a preliminary way, the question off orming a general organization of American chemists, who should thus constitute a national society. A general meeting of eighteen delegates representing seven different chemical organizations was held in connection with the general meeting of the American Chemical Society at the University of Pennsylvania, on the 30th of December. On the following day, a meeting of the chairmen of the various committees of conference was held at the Manufacturers' Club, in Philadelphia, and, as a result of the two meetings, a set of resolutions was adopted, a copy of which was submitted by Mr. Pemberton as a part of his report to the section.*

Inasmuch as another meeting of the various conference committees is provided for in the above-mentioned resolutions, the committee was continued for the performance of such duties as were implied in the resolutions. After Mr. Pemberton's report had been accepted, the president extended the thanks of the section to the committee for its action.

* Copy of these resolutions is appended.

The following gentlemen were proposed as candidates for membership in the section:

Mr. Geo. Guest Williams, Twenty-fourth and Bainbridge Streets, Philadelphia.

Mr. H. Warren Shepard, 523 Linden Street, Camden, N. J.

Mr. Everett W. Frazer, 915 Ridge Avenue, Philadelphia.

Mr. Edward Gudeman, 931 N. Twelfth Street, Philadelphia.

Mr. Harris Comer, 624 South Washington Square, Philadelphia.

Prof. Albion D. Gray, Penn Charter School, No. 8 S. Twelfth Street, Philadelphia.

Mr. Waldron Shapleigh, Welsbach Incandescent Gas Light Company, Gloucester, N. J.

Dr. Bruno Terné, Baugh & Sons' Chemical Works, Philadelphia.

Mr. Frank H. Rosengarten, Seventeenth and Bainbridge Streets, Philadelphia.

The names were voted upon by the committee on admission, and all were elected.

Mr. Lee K. Frankel then read a paper "On the electrolysis of the metallic sulpho-cyanides." (Referred for publication.)

Prof. Geo. A. Koenig followed with a paper, entitled "Is sulphuric hydrate volatile at ordinary temperatures?" It was also referred for publication.

Prof. Koenig's observations and experiments tended towards an affirmative answer of the question which formed the title of his paper, and some interesting discussion was evoked.

Dr. Tuttle referred to recorded experiments, in which the absence of change in solutions of barium salts, exposed to the possible evaporation of sulphuric acid tended to prove the non-volatility of the acid. Prof. Smith cited some observations made by himself in connection with electrically deposited mercury, in which a weight of 0·3 grams of that metal lost in the course of something less than twenty-four hours a weight of 0·002 grams presumably by evaporation.

The paper by Dr. Hans v. Strombeck, "On the specific heat of brines of different specific gravity; and on the determination of the specific heat of a body generally," was read by title and referred for publication.

A paper from Mr. J. M. Emanuel, U. S. N., "On the occurrence of amberite, ambrite or fossil gum, in a coal seam at Hawakawa colliery, Bay of Islands, N. Z., was read by the secretary, and was referred for publication.

Prof. Smith then presented a paper "On the electrolytic separation of certain metals in phosphate solutions." It was referred for publication.

After a number of interesting comments upon Prof. Smith's contribution, the section adjourned.

WM. C. DAY, *Secretary*.

Resolutions adopted at a conference of chemists, assembled for considering the formation of a national organization, held December 30 and 31, 1890, at the University of Pennsylvania, Philadelphia.

About eighteen delegates from the following chemical societies were present; to wit:

(1) American Association for the Advancement of Science, Chemical Section.
(2) American Chemical Society.
(3) Franklin Institute, Chemical Section.
(4) Brooklyn Institute, Chemical Section.
(5) Association of Official Agricultural Chemists.
(6) Chemical Society of Washington.
(7) Manufacturing Chemists' Association of the United States.

Prof. A. B. Prescott in the chair.

Resolution 1. It is desirable that an American Association of chemists be formed to embrace all existing American chemical organizations.

Resolution 2. Resolved that this conference recommend to all existing American chemical organizations that they call a meeting of their bodies to be held in Washington in connection with the meeting of the American Association for the Advancement of Science for 1891, and that each of these organizations be requested to appoint a committee, or to continue their present committee for the further discussion of the subject submitted to the conference now in session.

Resolution 3. Resolved that this general conference committee composed of the present sub-committees or such others as may be appointed by the several organizations, be called together at as early a time as practicable before the joint meeting recommended in the resolution adopted.

Resolution 4. Resolved that meanwhile each sub-committee, through its chairman, shall formulate such modifications of the constitution of the American Chemical Society as it shall deem necessary to adapt it to the requirements of the association proposed.

Resolution 5. Resolved that the chairmen of these sub-committees shall then, so far as possible, harmonize the views embodied in these reports of their several organizations, and shall have printed for presentation at the joint meeting a report, or majority and minority reports, on a constitution for the proposed association of American chemists.

Voted that the chairman of this conference, with Prof. Clarke and Prof. Hale, be a committee of three to select time and place for the meeting called for in resolution No. 3.

Voted to request the American Chemical Society to print the minutes of this conference in their proceedings of the Philadelphia meeting, and to mail copies as widely as possible to chemists in North America.

The secretary of this conference was desired to communicate the above resolutions to scientific journals with a view to obtain a wide publication of the same.

Adjourned to meet at call of the chair.

H. CARRINGTON BOLTON,
Secretary.

COMMITTEE OF CONFERENCE, WITH SOCIETIES REPRESENTED.

Dr. A. C. Peale, United States Geological Survey, Washington, D. C., representing the Chemical Society of Washington.

Prof. F. W. Clarke, United States Geological Survey, Washington, D. C., representing the American Association for the Advancement of Science.

Dr. H. W. Wiley, Department of Agriculture, Washington, D. C., representing the Official Agricultural Chemists' Association.

Mr. H. Pemberton, Jr., Twenty-ninth and Gray's Ferry Road, Philadelphia, Pa., representing the Chemical Section of the Franklin Institute.

Mr. Henry Bower, Twenty-ninth and Gray's Ferry Road, Philadelphia, Pa., representing the Manufacturing Chemists' Association of the United States.

Dr. Walter H. Kent, 64 Livingston Street, Brooklyn, N. Y., representing the Brooklyn Institute.

Dr. E. Waller, School of Mines, Columbia College, New York city, representing the American Chemical Society.

THE ELECTROLYSIS OF THE METALLIC SULPHOCYANIDES.

BY LEE K. FRANKEL.

[*Read before the Chemical Section, January 20, 1891.*]

In a paper published by Dr. Smith and the author, in the Franklin Institute *Journal* for August, 1889, the statement is made that manganese, when deposited from a solution containing an excess of potassium sulphocyanide, separates as a grayish white compact deposit on the negative pole, differing in this respect from solutions of the nitrate or the sulphate from which manganese is deposited as oxide. Furthermore, it is stated that nickel, cobalt, iron and several other metals separate very rapidly from cold sulphocyanide solutions under the influence of a weak current. In the following paper, the above experiments have been repeated, and the action of the current has been tried on various other metallic sulphocyanides. The results obtained have been, for the most part, of a negative order, but are here appended, as they illustrate some new facts in electro-chemical analysis.

Decomposition of Alkaline Sulphocyanides.—If a concentrated aqueous solution of potassium or ammonium sulpho-

cyanides (300 grams in one litre) is subjected to the action of a weak current (1·5 cc. OH gas per minute), the solution at first remains clear. After from one to two hours it gradually becomes turbid, and an odor of hydrocyanic acid is readily perceptible. If the current is allowed to run for twelve hours, the turbidity constantly increases until, at length, the solution is filled with a lemon-yellow amorphous deposit. According to Bunge (*Ber.* 3, 297), who investigated the action of the current on potassium sulphocyanide, and to Lidow (*Ber.* 17, ref. 252), who obtained similar results with ammonium sulphocyanide, this yellow deposit is pseudosulphocyanogen.

If, however, the solution, while being electrolized, is heated on a water-bath, there is evolved along with the pseudosulphocyanogen an unbearable sickening odor, due in all probability to the formation of organic sulphur compounds. In dilute sulphocyanide solutions, however, the formation of the lemon-yellow compound takes place in but small quantities, and only after the lapse of considerable time, so that if the current be sufficiently weak and the solution sufficiently dilute, no turbidity whatever occurs in the solution. It was anticipated that this behavior of the dilute solution could be utilized for the electrolytic deposition of the metals, but the other products of decomposition exerted such an influence on the solution that in but very few cases were quantitative results obtained. These are given below as they were found.

Mercury.—Mercury can be completely deposited from solutions of potassium or ammonium sulphocyanide. The metal separates very rapidly from the respective solutions, and resembles the deposit obtained in the electrolysis of the double cyanide of mercury and potassium, in that it never possesses a drop-like appearance, but is dense and coherent.

In the first determination a slight turbidity occurred, due to the larger quantity of ammonium sulphocyanide. The filtrates from all the four determinations gave the blood-red color with ferric chloride, but did not darken on the addition of ammonium sulphide. The deposits were washed,

first with cold then with hot water, and eventually dried on the edge of a warm iron plate.

	Mercury Present in Grams.	Ammonium Sulphocyanide in Grams.	Time.	Current per Minute.	Dilution.	Mercury Found in Grams.
(1)	·2292	1·5	16 hours.	1· cc. OH gas	75 cc.	·2289
(2)	·2292	·9	16 hours.	1·4 cc. OH gas	75 cc.	·2285
(3)	·2292	·9	16 hours.	·65 cc. OH gas	75 cc.	·2295
(4)	·2292	1·2	16 hours.	·65 cc. OH gas	75 cc.	·2294

Gold.—Like mercury, gold can be completely deposited from a solution of ammonium sulphocyanide. The metal separates as a compact, firmly adherent deposit, which can readily be washed with either hot or cold water. The conditions, under which the deposits were obtained, are as follows:

(1) To a solution of gold chloride containing 0·0185 gram of gold, 1·5 grams of ammonium sulphocyanide were added, along with 150 cc. of water. A current of 1 cc. OH gas per minute was allowed to act for six hours, at the end of which time, the metal was completely deposited. The gold found weighed 0·0183 gram.

(2) The conditions in this determination were like the above, excepting that the gold chloride solution contained ·1443 gram of gold, and that the current was allowed to act for sixteen hours. The resultant gold weighed ·1439 gram.

Cadmium.—If ammonium sulphocyanide is added to a solution of cadmium sulphate, the solution remains clear. If this solution be now subjected to the action of the current, the cadmium immediately deposits as metal, but in a very spongy form. This sponginess is frequently of such an extent, that the deposit spreads in a continuous layer from the negative to the positive pole, and readily detaches itself when washed. Various conditions of current and solution were tried in order to remedy this result, the current used varying from 0·25 cc. to 2·2 cc. OH gas per minute, and the amount of ammonium sulphocyanide from ·3 gram to

six grams in solutions diluted from fifty to 200 cc. In all cases, however, the cadmium deposited in a spongy form, and the method had to be abandoned.

Palladium, Nickel, Cobalt and Zinc.—In the electrolysis of neutral solutions of these four metals in the presence of ammonium sulphocyanide, similar reactions took place. In each instance, the metal began to deposit immediately with currents ranging from one to two cc. OH gas per minute, in solutions averaging one gram of ammonium sulphocyanide. In the case of the nickel and the cobalt, the metals deposited in a compact metallic form, and frequently could be separated as a thin film from the sides of the platinum dish. With all four metals, however, the deposition continued only to a certain point, after which a reverse action took place and the coatings gradually dissolved. In the case of the zinc, after permitting the current to act for twenty-four hours, every portion of the gray metallic deposit obtained in the earlier stage of the operation had gone into solution. The probable cause for this singular action lies in the fact that in the decomposition of the alkaline sulphocyanides, there is formed an estimable amount of alkaline cyanide which, in the experiments above referred to, could be easily recognized by its odor. The addition of ammonia to the solution from time to time during the passing of the current, gave no beneficial results, and all attempts to deposit the metals completely, with the strength of current used, proved futile.

Iron and Manganese.—The continuation of the investigation previously reported on these metals, led to no satisfactory results. As has been stated, the metals can be deposited from solutions of their sulphocyanides, but not completely, and the tendency to oxidize is so great, that films of the oxides form on the edges of the solutions, even during the action of the current. As soon as the solutions are poured off, and the surfaces of the metals are exposed to the air, these films of oxide rapidly spread over the entire deposits, and exclude any possibility of the estimation of iron or manganese by this method.

Arsenic.—Varying quantities of ammonium sulphocyanide

were added to solutions of sodium arsenate and of sodium arsenite made alkaline with sodium hydrate. In no case was there the faintest deposition of metal.

Lead.—It has already been shown that when a solution of lead nitrate is subjected to the action of the electric current, the lead will deposit as peroxide on the positive pole. If, now, ammonium sulphocyanide be added to the solution, while the current is passing the lead will deport itself similarly to the manganese, in that the peroxide of lead gradually dissolves off the anode, while the metal deposits on the cathode. This deposition of metal will continue until no more lead can be detected in the filtrate, but, while the greater portion of the lead has separated as metal on the negative pole, a white coating will now be found on the positive pole, which after solution in acids, gives a reaction with hydrogen sulphide for lead. This coating on the anode prevents any quantitative estimation of lead in an ammonium sulphocyanide solution. The metal as deposited from such a solution has a gray metallic appearance, is but loosely adherent to the dish, and easily becomes covered with a yellow film of oxide.

Antimony, Bismuth and Tin.—To the hydrochloric acid solutions of these metals, ammonia was added until precipitates formed, varying quantities of ammonium sulphocyanide were then added to the respective solutions, followed by hydrochloric acid, until the precipitates just dissolved. All three metals deposit rapidly from such solutions, the tin, however, but incompletely. The filtrate from the bismuth gave no reaction for the metal, but the deposit was so spongy that it could not be handled. The antimony deposit detached itself so readily from the sides of the dish on which it separated, that no effort was made to discover if quantitative results could be obtained.

Pseudosulphocyanogen.—In a paper on the preparation of a new yellow dye color, H. O. Miller (*Ber.* 18, ref. 676) states that the impure compounds, which he designates "Kanarin," is obtained by the action of hydrochloric acid and potassium chlorate on potassium sulphocyanide. The resulting yellow substance dissolves in potassium hydrate

solution, from which alcohol deposits the potassium salt. If the latter is filtered off and dissolved in water, hydrochloric acid reprecipitates the dyestuff. As noted above, Lidow (*Ber.* 17, ref. 252) asserts that the yellow amorphous compound obtained in the electrolysis of ammonium sulphocyanide is pseudosulphocyanogen, the yield being greatest at 50° C., and, furthermore, states that kanarin and pseudosulphocyanogen are identical.

In a still later paper, W. Markonikow (*Ber.* 17, ref. 279) denies that kanarin and pseudosulphocyanogen are identical bodies. In proof of this, he states that if pseudosulphocyanogen is dissolved in an equal volume of potassium hydrate diluted with twenty parts of water, it is converted into potassium sulphocyanide and potassium cyanate, while if kanarin undergoes a similar treatment, the potassium salt is obtained, which, as above stated, can be precipitated by alcohol. To prove the correctness or fallacy of these statements, the following experiments were made:

A solution of ammonium sulphocyanide, containing 300 grams of the salt dissolved in a litre of water, was electrolized with a current generating two cc. OH gas per minute, for forty-eight hours. The yellow compound, which had separated, was filtered off and washed with hot water, until the washings no longer gave the blood-red coloration with a solution of ferric chloride, and dried at 100° C. The resulting lemon-yellow compound dissolved readily in concentrated sulphuric acid, but without any evolution of sulphur dioxide, a reaction which Markonikow gives as distinctive for kanarin. The yellow substance dissolves in potassium hydrate, more readily on heating, to a yellow solution. A portion of this solution, after acidifying with dilute nitric acid, and the addition of ferric chloride, gave not the faintest reaction for potassium sulphocyanide. To the remainder of the solution, alcohol was added. The turbidity that formed, gradually settled to the bottom of the liquid in oily drops. These were separated from the supernatant liquid by means of a separatory funnel, dissolved in water, and from this solution the lemon-yellow compound thrown out by means of hydrochloric acid. If

these reactions are indicative, kanarin and pseudosulphocyanogen are identical, but the compound obtained in the electrolysis of ammonium sulphocyanide is not pseudosulphocyanogen.

The action of potassium chlorate and hydrochloric acid on ammonium sulphocyanide was also tried, the results being similar to those obtained by Miller and Markonikow with potassium sulphocyanide. The compound thus obtained has a reddish yellow color, dissolves in potassium hydrate, the resulting solution giving a reaction for potassium sulphocyanide, and forming the potassium salt with alcohol, showing that the original substance is impure. The potassium salt dissolved in water, and treated with hydrochloric acid, now gives a lemon-yellow precipitate resembling in color that obtained by the electrolysis of the ammonium sulphocyanide.

The author reserves, for a future communication, the investigation of the composition of these compounds, and in conclusion wishes to extend his thanks to Dr. Edgar F. Smith, under whose supervision, and at whose instance, the above work was undertaken.

UNIVERSITY OF PENNSYLVANIA,
PHILADELPHIA, January 13, 1891.

ANNUAL REPORT OF THE BOARD OF MANAGERS OF THE FRANKLIN INSTITUTE.

(For the year 1890.)

The Board of Managers of the Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts, respectfully presents the following report of the operations of the institute for the year 1890:

MEMBERS.

Members at the close of 1889,	2,224	
Number of new members elected who have paid their dues,	192	2,416
Lost by death or resignation,	89	
Dropped for non-payment of dues,	158	247
Total membership at close of 1890,		2,169

FINANCIAL STATEMENT.

Balance on hand January 1, 1890,		$2,172 33
Receipts:		
Contributions from members,	$6,679 75	
Certificates of stock, second class,	30 00	
Interest on investments of institute's funds,	1,654 00	
Interest on investments of building fund,	353 09	
Temporary loan,	2,000 00	
Cash from other sources,	9,264 39	
		19,981 23
		$22,153 56
Payments:		
Committee on library,	$2,366 13	
Committee on instruction,	2,236 77	
Curators,	1,938 37	
Salaries and wages,	4,145 00	
Insurance,	450 00	
Temporary loan,	2,000 00	
Interest on temporary loan,	60 97	
Other expenditures,	8,298 61	
		21,495 85
Balance on hand December 31, 1890,		$657 71

LIBRARY.

The annual report of the committee on library shows that the additions to the institute's collections of books, pamphlets, maps, etc., during the past year were fully up to the average of recent years, the total increase amounting to 3,229 numbers.

There has been no change in the policy of the committee in respect of the use of the library by the public. The plan in force now for three years is found to work well and gives general satisfaction. The best evidences of this are the increasing use of the library by non-members, and the fact that no case has thus far occurred of the abuse of the privileges accorded to non-members. For the details of the year's operations the board refers to the committee's report.

COMMITTEE ON SCIENCE AND THE ARTS.

This committee has continued the excellent work recorded in last year's report. The efficiency of its present methods, and the thoroughness of its investigations are plainly visible in the character of the subjects submitted for examination. A number of the committee's reports appears in the *Journal* and reflects credit upon the institute. The excellent work accomplished by this committee since its reorganization in 1887, has fully justified the expectations of those who anticipated that further usefulness would result from the changes then made.

The members are referred, for details of the committee's work, to the chairman's report.

SECTIONS.

The Chemical Section continues in the flourishing condition noted in the report of 1889. Its activity is apparent in the pages of the *Journal* and the board expresses its gratification at the excellent record the section has made.

Near the close of the year 1890, the board favorably acted on the petition of a number of members of the institute to establish an electrical section, and the institute at its last stated meeting approved the action. The board may hope, therefore, that in the next annual report the new section will be referred to as another useful auxiliary in furthering the objects of the institute.

The details of the work of the Chemical Section may be found in its annual report.

THE JOURNAL.

The board refers with satisfaction to the condition of the *Journal*, both in respect of the manner in which the committee on publications and the secretary have sustained its high reputation, and in respect of its business condition. In regard to the last, the board may report in view of the steady improvement that has been going on in the past few years, that the *Journal* is self-supporting, and there is no reason why, with the same intelligent direction of its affairs, it should not so continue. The board again takes the opportunity of commending the *Journal* to the members of the institute as worthy of their generous support.

LECTURES.

The committee on instruction has adhered generally to the policy of arranging a series of lectures, with especial reference to the presentation of the latest and most important subjects of technical interest. The character of many of these lectures has been such as to afford admirable material for the *Journal*, and to contribute to the reputation of the institute. In this work, the committee, through the able efforts of its professors, has been able, as heretofore, to command the services of many eminent scientists and engineers.

During the past year the following lectures were delivered:

January	6.	Prof. F. W. Clarke, "The Chemistry of Coal."
	13.	Prof. R. L. Chase, "A Revolution in Dyeing."
	17.	Prof. W. Le Conte W. Stevens, "The Mammoth Cave of Kentucky.
	20.	Lieut. Bradley A. Fiske, "Electricity in Warfare."
	27.	Dr. W. Thomson, "Color-Blindness."
	31.	Mr. C. John Hexamer, "A Descriptive and Illustrated Sketch of Germany."
February	3.	Dr. Louis Duncan, "Modern Conceptions of Electricity."
	7.	Mr. Theo. C. Search, "Wool, from the Fleece to the Card."
	10.	Mr. Eugene Griffin, "Electric Railways."
	14.	Mr. Theo. C. Search, "Wool, from the Card to the Fabric."
	17.	Mr. Geo. F. Kunz, "Precious Stones."
	21.	Mr. Wm. F. Durfee, "Diamond Drilling."
	24.	Dr. Chas. B. Dudley, "Bearing-Metal Alloys."
	28.	Mr. Fred. E. Ives, "Street Scenes in Italy, caught with the Camera."
November	10.	Prof. Persifor Frazer, "Some Helps and Hinderances to the Progress of Theoretical Chemistry."
	14.	Mr. C. John Hexamer, "From the Baltic to the Volga."
	17.	Dr. H. Hensoldt, "Some Geological and Cosmical Problems."
	21.	Prof. Edward D. Cope, "The Zoölogical Characters of Man."
	24.	Dr. Bruno Terne, "Ammonia: its Sources and Technical Uses."
	28.	Mr. Edwin S. Checkley, "A Natural Method of Physical Culture."
December	1.	Prof. G. G. Groff, "The Organization of Sanitary Work in Cases of National Disaster."
	5.	Dr. L. Webster Fox, "Eyesight: its Care during Infancy and Youth."
	8.	Capt. F. A. Mahan, "Philadelphia as a Seaport."
	12.	Mr. J. C. Trautwine, "Engineering Notes from Europe."
	15.	Prof. Wm. D. Marks, "Two and a Half Miles a Minute.'
	19.	Mr. Fred. E. Ives, "Photography in the Colors of Nature."
	29.	Dr. A. Victoria Scott (a Christmas lecture for children), "A Trip to Alaska."

DRAWING SCHOOL.

The number of pupils in the drawing school was the largest in its history, and the board expresses its entire satisfaction with its condition.

The figures representing the attendance of pupils are as follows:

At the spring term of 1890,	178
At the winter term,	295
Total attendance for the year,	473

being an increase of 86 over the number for the year 1889.

STATE WEATHER SERVICE.

The work of this branch of the institute has been continued as heretofore. The liberal grant of funds by the state for the carrying on of this service has enabled the committee on meteorology to make more elaborate and valuable publications of the results of its work, and steadily to increase the efficiency of the service. The value of the service is generally recognized and there is every reason to believe that it will become a permanent institution. The change made by the last Congress in transferring the United States Weather Service to the Department of Agriculture is not expected to cause any modification in the relations of the Washington Bureau to the several State Weather Services.

GENERAL REMARKS.

The board regrets that the great increase in receipts from new memberships as shown by last year's report and which there was every reason to hope would continue, does not appear this year. As a consequence, the financial condition of the institute at the end of 1890 is not as gratifying as at its beginning. Practically, there is no more feasible way of immediately benefiting the institute than by obtaining new members, and with the large field from which to draw and the little effort necessary to bring them in, it is a matter of some mortification that better results are not obtained.

The board reports receipt of a legacy from the late Geo. S. Pepper, amounting to about $23,815.05, and the prospect of an additional sum from the residuary. The income from this legacy will be of assistance in the maintenance of the institute work.

The board deplores the failure of the effort that has been made to obtain subscriptions to the building fund, conditioned upon the sum of $100,000 being raised before the end of the year 1890. The financial state of the country during the past few months has made success impossible. It is hoped that with renewed prosperity in business circles a second effort may be made and the desired result attained. Nothing stronger can be said upon this subject than that contained in the last report, and the board urges upon the committee in charge to recommence its work with fresh vigor as soon as practicable.

In closing its report, the board desires to express its grateful acknowledgment of the benefits accruing to the library from the increased income

available from the Bloomfield H. Moore fund, which, through the recent gift of Mrs. Clara Bloomfield Moore, has been almost doubled.

A like expression of grateful acknowledgment is due, and is hereby tendered, to the family and executors of the late George S. Pepper.

By order of the board.

JOSEPH M. WILSON, *President.*

ABSTRACT FROM THE ANNUAL REPORT OF THE COMMITTEE ON LIBRARY.

(For the year 1890.)

During the year the following additions were made to the library :

Volumes bound,	1,080	
Volumes unbound,	630	
Pamphlets,	1,350	
Total,		3,060
Maps and charts,	179	
Photographs and lithographs,	11	
Newspaper clippings,	4	
Circulars,	45	
Total additions of all kinds,		3,299
Total number of volumes in the library at the close of 1889,	33,305	
Additions, bound and unbound volumes, 1890,	1,710	
Total number of volumes in the library at close of 1890,		35,015
Pamphlets.—Total number in the library, December 31, 1889,	19,622	
Add those received in 1890,	1,350	
Total,		20,972
Total number of maps and charts at the close of 1890,		1,962
Designs and drawings,		603
Photographs and lithographs,		1,050
Newspaper clippings,		116
Circulars,		98
Manuscripts,		21

Duplicates.—The number of duplicates on hand at the close of 1890: Volumes, 2,762; pamphlets, 5,857; charts, 169; periodicals, 8,022.

Moore fund.—During the year 132 volumes, 126 unbound volumes and 4 pamphlets were purchased with this fund. Six volumes were rebound and one was repaired.

Public use of the library.—891 receipts were filed by non-members during the year, consulting 2,472 volumes of patents, 534 numbers of the official gazette, 942 volumes and 43 pamphlets from the other departments of the library.

Circulation.—2,037 volumes were issued to members for home use, an increase of 348 over 1889, and 788 over 1888.

Exchanges.—The number during 1890 amounted to 380, an increase of 4 compared with the previous year.

By order of the Committee on Library,

WM. H. WAHL, *Secretary.*

ANNUAL REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS.

The chairman of the Committee on Science and the Arts respectfully makes the following report of the work of the committee for the year 1890:

The total number of new applications received during the year was sixty-two, of which fifty-five were approved for investigation, six rejected by the preliminary committee and one withdrawn. Thirty-four reports have been acted upon during the year and forty are still pending.

In four cases the award of the Elliott Cresson medal was recommended; in eleven, the John Scott legacy medal and premium, and in two, certificates of merit, and in the reports completed and now pending there are two awards of the Elliott Cresson medal and three of the John Scott legacy medal and premium.

Protests have been received to three of the awards of the committee, two of which, after investigation, were not sustained, and the third was withdrawn.

The foundation of the Edward Longstreth medal of merit, through the liberality of Mr. Edward Longstreth, will add greatly to the resources of the committee, in enabling it to make an award in many deserving cases which the regulations governing the awards, heretofore in the control of the committee, prohibited.

The committee deemed it best to amend its by-laws by inserting a provision forbidding members of the committee to receive awards except in cases where the institute directed that the investigation should be made.

The committee has undertaken to investigate the subject of hot-water boilers for heating purposes, and a sub-committee is now at work preparing a code for testing such boilers.

The index of the work of the committee from 1834 to 1890 has been completed and published, and the reports are now available for reference. The thanks of the committee are due to Mr. S. Lloyd Wiegand, one of its members, for the interest and labor he has expended in the execution of this work.

Respectfully submitted,

H. W. SPANGLER,

Ch. Com. Sci. and Arts.

REPORT OF THE CHEMICAL SECTION OF THE FRANKLIN INSTITUTE FOR THE YEAR 1890.

Mr. Joseph M. Wilson, president Franklin Institute.

SIR:—I have the honor to submit the following report of the proceedings of the Chemical Section, for the year 1890.

The progress of the section during the year has been highly gratifying to its members, and while the report for 1889 showed for that period a condition of prosperity unprecedented in the history of the section, it is none the less true that the past year has entirely fulfilled the sanguine expectations of its members and all others interested in its progress and welfare.

The work of the section was prosecuted with the aid of the following officers:

President,	Mr. T. C. PALMER.
Vice-presidents,	DR. H. F. KELLER, MR. W. L. ROWLAND.
Secretary,	DR. WM. C. DAY.
Treasurer,	DR. H. W. JAYNE.
Conservator,	DR. WM. H. WAHL.

Stated meetings were held, as required by the by-laws of the section, on the third Tuesday of each month of the year, excepting July and August.

Membership.—The number of members, according to the treasurer's books, at the beginning of the year, was seventy-one; the number at present enrolled is seventy-two, three new members having been elected, while two have resigned.

Finances.—The report of the treasurer, submitted to the section at its last meeting, shows total receipts from various sources during the year amounting to $138 00

Cash on hand at beginning of the year, ... 91 50

$229 50

Disbursements amounted to 132 17

thus leaving a cash balance of $97 33

in the hands of the treasurer at the end of the year.

Attendance at meetings.—The meetings have been well attended by the members, and in almost every case the presence of a number of visitors has served to indicate the interest taken in the section by its outside friends.

Journals received by the section.—Early in the year the library committee authorized the purchase for the section of a complete set of *Liebig's Annalen* from 1832 to 1886. Subscription for this journal, beginning with 1887, was made by the section; this periodical, so essential as an auxiliary to scientific investigation, is therefore now complete.

Owing to the very satisfactory condition of the section's treasury, it has been found practicable during the year to add to the list of journals previously taken by the section the following, which are at present regularly received, viz: *Chemisches Centralblatt, Liebig's Annalen der Chemie, Zeitschrift für physiologische Chemie, Zeitschrift für Krystallographie, Tschermak's mineral-*

ogische Mittheilungen, Búlletin de la Sociètè Chimique, Gazzetta Chimica Italiana.

That the influence of the Chemical Section is making itself felt not only in Philadelphia and neighboring cities, but throughout the country, follows from the expressions of interest which in one way or another frequently have come to the notice of its members. Papers from writers in distant cities have been forwarded for consideration by the section and subsequent publication in the *Journal.*

Applications for membership from persons at a distance have also been made.

In view of these facts, the section has, at a recent meeting, appointed a committee for the purpose of considering means by which the attention of chemists at large may be called to the facilities for prompt publication which the institute possesses.

During the year, sixteen important papers, giving the results of original investigations, have been read before the section. Nine communications of a miscellaneous character have been presented; thus making in all twenty-five matters of scientific interest which have occupied the attention of the section.

Very respectfully submitted,

WM. C. DAY, *Secretary.*

Franklin Institute.

[*Proceedings of the annual meeting, held Wednesday, January 21, 1891.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 21, 1891.

JOS. M. WILSON, president, in the chair.

Present, 244 members and twenty-two visitors.

Additions to membership since last report, eleven.

The annual reports of the Board of Managers, the Committee on Library, the Committee on Science and the Arts and the Chemical Section were presented and accepted. (For these reports, see *ante.*)

The secretary, by direction of the Committee on Science and the Arts, presented the report of the committee in reference to the regulations for the grant of the Edward Longstreth medal of merit. On motion the committee's action was confirmed and the regulations proposed in the report were approved.

On motion, the grant of the Edward Longstreth medal of merit, recommended by the committee to the Menlo Park Ceramic Works, for their decorative tiles and faience work, was approved.

A letter from Dr. Francis Fowler, of Washington, D. C., was read, accepting his election as an honorary member.

Mr. S. Lloyd Wiegand read a paper on the Olsen testing machine. The speaker described the machine with the aid of lantern slides, exhibiting the

details of construction, and illustrated its operation by reference to a machine of large capacity that was mounted upon the platform. Several pieces of steel were tested by tensile stress, and an interesting feature of the machine, by which a continuous graphical record of the behavior of the test-piece is made, was exhibited. The speaker alluded to the fact that the Committee on Science and the Arts had lately recommended the grant of the Elliott Cresson medal to the inventor of this machine. (Referred for publication.)

Mr. Wm. B. LeVan presented an abstract of a paper, entitled Fast Trains, in which he gave an account of some remarkable performances of English locomotives, and advocated higher speeds upon American railways. (Referred for publication.)

Mr. Edmund Stirling exhibited and described briefly, a suite of colored lantern slides of Japanese subjects, made by native artists. These views were loaned for the purpose by Dr. Edward Williams, and were greatly admired for the exquisite delicacy of the coloring.

Mr. Frederick E. Ives, by request, exhibited, with the lantern, some specimens of photographs in the colors of nature, made by his process of heliochromy, and briefly described his method.

The secretary referred to the receipt of a communication from Mr. J. M. Emanuel, P. A. Eng., U. S. N., member of the institute, describing the occurrence of amberite (or ambrite), a fossil gum, in a specimen of coal from New Zealand. A specimen of the coal containing a mass of the gum was shown.

The secretary exhibited and described a flexible metallic tube, invented by Mr. T. R. Almond, of Brooklyn, N. Y.

The following amendments to the by-laws of the institute, recommended for adoption by the managers, were read, viz:

Section 8 of *Article III*, shall read as follows: Non-resident members shall be those who reside permanently at a distance not less than fifty miles from Philadelphia.

Holders of second class stock, contributing members and candidates for membership, wishing to be classed as non-resident members, are required to present a request therefor to the Board of Managers, which may at its discretion grant the request. No person, however, shall be enrolled as a non-resident member, who may reside for a portion of the year in Philadelphia, and no request for such enrolment shall be granted to any holder of second class stock or contributing member who may temporarily be absent from the city for a period of less than one year.

Section 1, Article IV.—Insert after the words five dollars, "except as hereinafter provided." [The section, as amended, would read: "Every member, other than a holder of second class stock, shall pay an annual contribution of five dollars, except as hereinafter provided, but the payment of fifty dollars within any one year shall constitute a member for life, with an exemption from all annual payments.]

Section 2, Article IV, shall read as follows: Holders of second class stock and contributing members enrolled as non-resident members shall pay upon election to membership an entrance fee of five dollars and an annual fee of two dollars.

Present *Section 2*, of *Article IV*, shall be designated Section 3.

Present *Section 3*, of *Article IV*, shall be designated Section 4.